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FIREPROOFING OF BUILDINGS
STAIR BUILDING
ORNAMENTAL METAL WORK
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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one select the proper formula, method, or process and in teaching him how and when it should be used.

This volume contains information useful to all architects, but especially adapted for the purposes of the designer of office buildings, mills, and the higher class of residences. The modern office building is made with fireproof floors and partitions. Next to floors and partitions, probably the most important matters to be considered in connection with the interior construction of the building proper are the hardware and ornamental metal. All these subjects are carefully explained at length. The volume also takes up the subject of mill design from its various aspects of economy, safety, stability, etc. This is a subject with which few architects are conversant, although it is of increasing importance and opens a lucrative field for the progressive designer to enter.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part, when the subject is divided into two or more parts, is complete in itself; hence, in order to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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FIREPROOFING OF BUILDINGS

FIREPROOFING MATERIALS

INTRODUCTION

1. As the materials made use of in modern fireproof construction to protect the structural parts of buildings from fire and heat come within the province of the architect, a good knowledge of the systems and methods of fireproofing in use is necessary for the intelligent design and direction of the work.

The term *fireproofing* is misleading. For instance, the materials of which part of a building is constructed may not be inflammable in themselves, still they may be destroyed by fire or else afford insufficient protection to other and combustible materials. A material is not a fireproofing substance simply because it is incombustible. A marble-slab floor in itself will not burn, yet it would be entirely unfit for use after passing through a severe fire; in fact, it would probably fail during the conflagration.

The material that is stored or contained in a building greatly affects its fireproof qualities. No building can be absolutely fireproof unless its contents will not burn. A steel fireproof building in which celluloid is manufactured would not be so safe as a wooden building in which bricks are stored. It can thus be seen that the word fireproof is at best a relative term.

2. Before the plans for a fireproof building are made, the materials and method of construction to be used should

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be decided on, as some fireproof systems require particular arrangement of the supporting members.

The principal fireproof materials used in building construction are brick, terra-cotta tiles, and concrete, the latter being usually bound together and strengthened by steel bars, wire, or netting. Nearly all methods of fireproofing are covered by patents owned by manufacturing concerns, which usually undertake to supply and set all the fireproof material used in a building. This plan is productive of much better results than when the work is done by inexperienced contractors.

USE OF MATERIALS

3. Brick and Steel Fireproofing.—Brick arches and steel beams were the first materials used in modern fireproof-floor construction. The steel beams are spaced 4 or 5 feet apart, and from their lower flanges brick arches are sprung, having usually a rise in inches equal to the span in feet. The thrust of the arches is taken up by abutting arches or by tie-rods, which are spaced every 4 or 5 feet along the length of the steel beams. The haunches above the arches are filled with concrete, which is made level with the top of the steel beams, and the flooring is placed on sleepers embedded in the concrete.

Brick is sometimes used to encase columns in the construction of fireproof vaults, and also to build walls that are used as fire-stops. As a fireproofing material, brickwork is excellent, but it has two serious disadvantages: cost and weight. Another possible disadvantage in the use of the brick arch is the fact that on being suddenly cooled the brick are liable to crack and break on account of the internal strains produced.

4. Terra-Cotta Fireproofing.—Terra-cotta tile arches are the outcome of efforts to use the refractory properties of brick clay in the production of a light and at the same time strong system of fireproofing and floor construction. Two kinds of terra cotta, known as *dense* and *porous*, are used for this purpose. The **dense tile** is made of selected clay in practically the same manner as brick, its superiority over brick being due to the hollow form in which it is molded. **Porous tile** is made of clay and sawdust or other combustible material. The compound is thoroughly mixed, molded into the required shapes, and when sufficiently dry is placed in kilns and subjected to intense heat, which consumes all the combustible material, leaving the brick or tile in a thoroughly porous condition and consequently making it much lighter than the dense tile. Because of their incombustible and non-conductive properties, terra-cotta products are very effective in preventing fire from spreading by confining it to one locality.

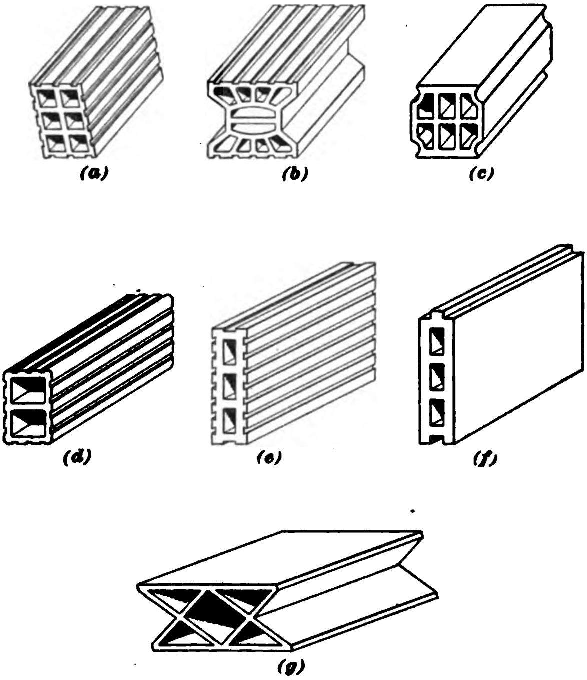
(a) (b) (c)
(d) (e) (f)
(g)

FIG. 1

In Fig. 1 are shown several forms of terra-cotta tile used in building construction: (*a*), (*b*), and (*c*) are the usual forms employed in floor systems; (*d*), (*e*), and (*f*) are the types used in the erection of fireproof partitions; and (*g*) is the tile often adopted in light floor construction. On account of the hollow construction of these tiles and the uniform thickness of the walls and webs, the clay is uniformly burned and the likelihood of internal strain in the material is slight. Porous tiles also possess the peculiar property of receiving nails readily and holding them with considerable tenacity, and are thus of great value in partition work.

Floor arches carefully constructed of the tiles shown in Fig. 1 (*a*), (*b*), and (*c*) have proved strong enough to sustain any load the floor has been required to carry. Both the dense and the porous tiles are used in floor systems, but the latter has the greater advantage, as it possesses more refractory properties, is as strong as the dense tile, and does not conduct heat so readily.

5. Expanded Metal and Woven Wire.—**Expanded metal** and **woven wire**, materials that are extensively used in fireproof construction, may be divided into two classes, according to the ends to be attained: first, those having comparatively large meshes and heavy strands, used in concrete floors, roofs, and similar places, where loads have to be carried; second, those having small meshes, with thin strands, used as lathing, on which mortar or other plastic material can be applied.

Woven wire and expanded metal have unlimited uses in supporting suspended ceilings, and are sometimes used to form a framework on which elaborate plastic decorations around beams and columns can be run, thus answering the double purpose of decoration and fireproofing.

6. Concrete.—Portland cement concrete withstands fire and water tests well, and may be considered a thoroughly fireproof material. The uses of concrete in fireproof construction can be divided into many classes of work, but the two of particular importance are reinforced construction and fireproof lathing and plastering. Mortars made of either lime or cement and applied on metal lathing will successfully endure a great degree of heat, and will also withstand the action of water.

7. Plaster of Paris.—**Calcined gypsum,** or **plaster of Paris,** is used in several fireproof-floor systems and also to protect columns and girders, where its adaptability to decorative work makes it especially desirable. This material is a non-conductor of heat and possesses the advantage that it can be cast in molds or worked into any shape. Plaster of Paris can be used as concrete, in slabs, supported between beams and reinforced by steel wires or rods, or it may be molded into lintels that are supported on skewbacks between the floorbeams. The lintels effectually fill the space when placed side by side, and possess the required strength when reinforced by woven wire or expanded metal. One system uses a segmental tile arch, which rests on the lower flanges of the I beams supporting the floor and forms a permanent centering on which concrete may be tamped; a strong floor system and finished ceiling are thus secured. In the construction of one floor system, wood shavings are introduced in the plaster of Paris with a view of lightening the composition and giving greater tenacity to the material.

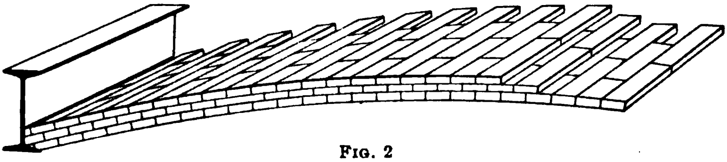

FIG. 2

8. Spanish Tile Arches.—**Spanish tile arches** are used in fireproof-floor, roof, and dome construction. They are particularly light, economical, and scientific in their design, and form the *Gustavino construction*, which is named after its inventor, a Spanish architect. Spanish tile arches consist essentially of three layers of tile, 1 inch thick, which are thoroughly embedded in cement and laid up in the form of a segmental arch, as shown in Fig. 2.

FIREPROOF CONSTRUCTION

CONSTRUCTION OF FLOORS AND CEILINGS

EARLY METHODS

9. Formerly, fireproof floors were made of concrete supported on brick arches sprung between the lower flanges of I beams, although in some cases corrugated-iron arches were substituted for the brick. The objections to these forms of construction are that the arches and the concrete are extremely heavy, the ceilings are not level, and the bottom flanges of the beams are unprotected. Consequently, a better form of construction was sought, and the brick- and iron-arch methods have been largely replaced by flat arches of dense and porous tile, with much saving in weight and more complete protection of the steelwork. Considerable improvement has been made during the past 10 years in the design of tile-floor arches, and a number of systems have been introduced. In all cases, the efforts of inventors have been directed toward securing a light and economical floor that will have sufficient strength and afford thorough fire protection.

TERRA-COTTA TILE ARCHES

10. Flat-Tile Arches.—At present three methods of constructing flat-tile floors are in use in the United States. The first is known as the *side method*, so called because in each transverse row the sides of the blocks abut those of the adjacent ones; the second is called the *end method*, the blocks being set end to end, at right angles to the beams; the third is a combination of the first and second, the length of the skewbacks being parallel with the beams, while the other blocks are set at right angles thereto.

11. Side-Method Arches.—The first tile arch was built about 1872 on the lines of what is known as the **side method,** and was somewhat similar in appearance to the one shown in Fig. 3. Although an improvement over the brick arch, this arch left much to be desired. The bottom was smooth and would not hold the plaster firmly; the beams were not protected beneath except by the plaster, which in case of fire was inadequate; and the entire thrust of the arch was taken up by the top and bottom web of each block.

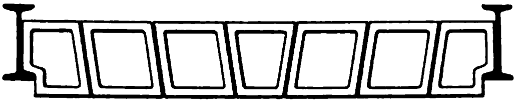

Fig. 3

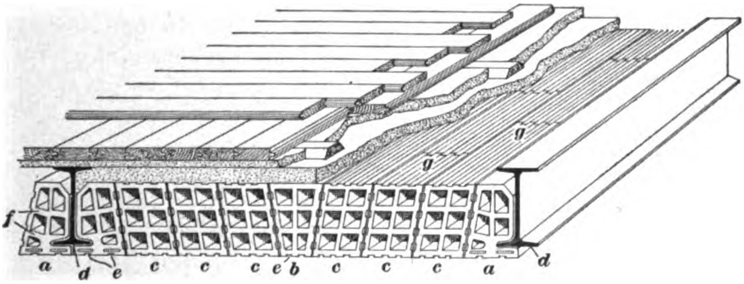

Fig. 4

12. The latest side-method arch is constructed as shown in Fig. 4. The dentil faces of the blocks shown at *e* serve to give them a better grip on the cement placed between them, on the concrete above, and on the plaster below. The blocks marked *a*, *a* are called *skewbacks;* those marked *c*, *c*, *lengtheners*, or *voussoirs;* and *b*, is the *key*. The skewbacks are made to protect the **I** beam, having a lip, as shown at *d*, *d*. Sometimes instead of using a lipped skewback the blocks are beveled and a *soffit tile*, as shown at *a*, Fig. 5, is employed. It will be noticed in Fig. 4 that the blocks are strengthened by two horizontal webs, as shown at *f*. These

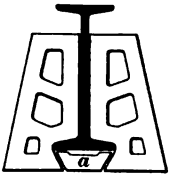

Fig. 5

tile blocks are laid with their joints *g*, *g* *staggered*, so as to give additional strength to the arch. When using a tile arch, it is necessary to fill the space above the tiles to the top of the **I** beams with some incombustible material, concrete being usually employed for the purpose. The sleepers to which the floor is nailed are generally made so as to run at right angles to the **I** beams, as shown in the illustration. These nailing strips are beveled and embedded in a layer of concrete equal in depth to their thickness, less $\frac{1}{4}$ inch clearance, and are thus held securely in place.

13. There is one objection to the side method of arch construction, however, and that is the vertical surfaces do not take up any of the strain; consequently, there is always a certain amount of dead weight to be carried. To overcome this objectionable feature and devise an arch in which all the material would assist in resisting the strain, the end-method arch was invented.

14. End-Method Arches.—Arches formed by the **end method** of construction are usually made of rectangular blocks that are divided by vertical and horizontal webs into four or more sections, and have beveled end joints. It is not customary to make the blocks in one transverse row break joints with those in the next, as the expense of setting would be thereby increased.

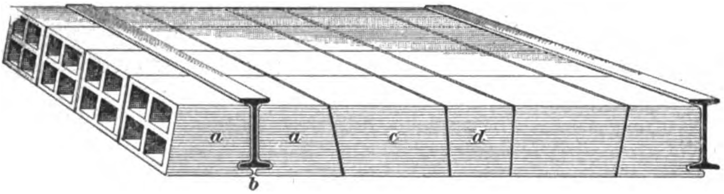

FIG. 6

Fig. 6 illustrates a very common type of the end-method arch. At *a* is shown the skewback, having a protective flange *b*; at *c*, one of the inside blocks; and, at *d*, the key block. This form of construction is economical and simple, as all the blocks in each longitudinal row of the arch are made alike.

Porous terra cotta is used almost exclusively in the manufacture of this type of arch.

15. One objection to the end method is the weight due to the thick webs that are necessary in order to obtain sufficient bearing to properly transmit the load to the beams. Another objection is that the mortar squeezes out from between the thin abutting surfaces, thus allowing some of the pieces to sink below the others and rendering it difficult to secure a flat surface for the ceiling. Furthermore, if any block is broken or removed, the row will fall, there being no longitudinal bond as in side-method arches. To obtain good bearings, the blocks should bear evenly against one another, being cut, if necessary, to set flat and give a level upper surface, and the webs also should be in line.

16. Fig. 7 shows a form of block in which greater bearing surface is provided than in that illustrated in Fig. 6. These blocks are made of dense tile and have braced top and bottom flanges $\frac{3}{4}$ inch thick, the webs and central horizontal partition being $\frac{1}{2}$ inch thick. A section of the block is shown at *a*, an end view at *b*, and a tie-rod at *c*. The lower part of the **I** beam is protected by a plate resting on the beveled lower edge of the skewbacks, as shown at *d*.

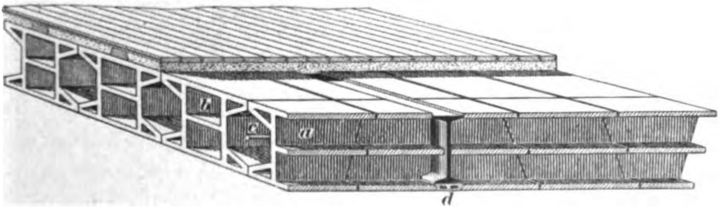

Fig. 7

17. Combination Arches.—The **combination method**, which is the improved system of flat-tile arch construction, is shown in Fig. 8. The air spaces in the hollow tile extend perpendicular to the steel floorbeams, except in the skewbacks, where they run parallel with the beams. The skewbacks *a*, *a* are practically the same as those employed in the side-method construction, but the voussoirs *c c* and key block *b* are considerably different, as they take a bearing on the end section and not on the side, and are of such a form that hollow spaces are provided between the tile in a direction perpendicular to the beam, as shown at *d*. These spaces, besides diminishing the weight of the system considerably, provide a means of passing the tie-rods through the arch from beam to beam.

The combination system is considered superior to the side or end method of construction because, for a given weight, it is stronger and is, consequently, a lighter system of flooring. The openings between the tiles readily permit the insertion of the tie-rods and allow any variation in their spacing; thus, the cutting of the tile is avoided and any risk of breakage likely to occur with the side method of construction is eliminated.

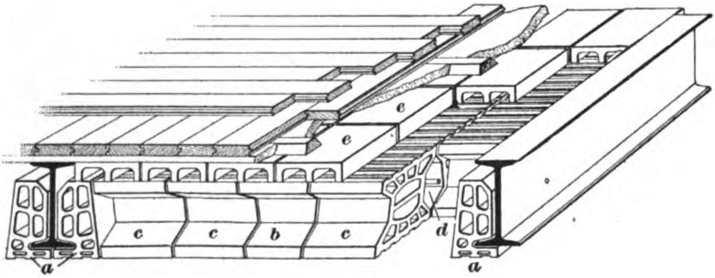

FIG. 8

At *e*, *e*, Fig. 8, are shown pieces of terra cotta, known as *hollow-tile fillers*, that take the place of concrete and make the entire construction lighter. The nailing strips are placed directly on top of these fillers, and are held in place as usual by concrete.

18. Tie-rods are necessary in all floor arches to prevent the beams from spreading. They are placed from 5 to 7 feet apart, and are generally $\frac{3}{4}$-inch rods that are threaded at the ends and provided with nuts to take up the thrust of the arch. These rods should be placed in the web of the beam, as near as possible to the lower flange.

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19. Another combination arch, which is considered very strong and durable, is illustrated in Fig. 9. At *a* is shown the strongly braced skewback, having three or more webs; at *b*, the inside blocks, laid end to end; at *c*, the side-method key; and at *d*, the beam protection, formed in two pieces separate from the skewbacks. The side and end surfaces of the blocks are corrugated, thus permitting the insertion of mortar and preventing the pieces from slipping past one another.

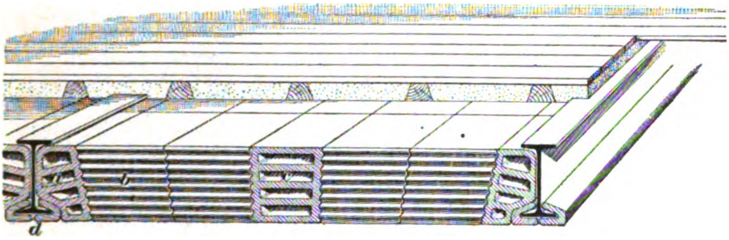


FIG. 9

DETAILS OF CONSTRUCTION

20. Centering for Flat Arches.—To support the blocks during laying, a firm **centering** is needed. A good form, shown in Fig. 10, is made of 1-inch boards *a*, dressed and set close together and resting on a 4″ × 4″ or 4″ × 6″ piece *b* which extends parallel with the beams and midway

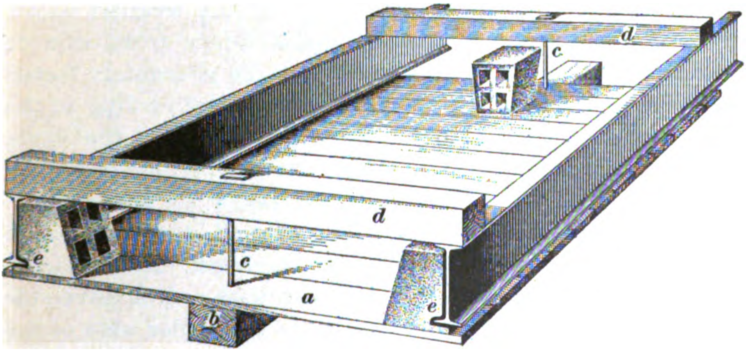


FIG. 10

between them. The piece *b* is suspended by **T**-headed bolts *c* from similar pieces *d*, which are laid across the top of the beams. The tiles forming the **I**-beam protection are put in place first and if they are separate pieces, are laid on the planks directly beneath the beams; or, if the **I** beams are protected by the skewbacks, as at *e*, the latter are set. The bolts are then tightened so as to bend the planks slightly, forming the camber, which crowning should be about ¼ inch for a 6-foot span.

In setting the blocks, the pieces should be adjusted so that the surfaces will abut properly. Only the best cement mortar should be used, and the joints should be made thin, but care should be taken that the mortar does not become pressed out. The centering should be kept in place until the mortar between the blocks has set, which takes from 12 to 36 hours. When the centering is removed, the arch should have a level surface, showing no open joints or projecting blocks. If holes in the floor are required, they may be punched in the blocks and closed afterwards with broken tile and mortar; or, if the side-method arch is laid, a block may be temporarily omitted.

21. Care in Laying Arches.—Like all other masonry work, floor arches should not be laid in cold weather unless ample protection is provided against injury from rain or snow; otherwise, the mortar is likely to be alternately frozen and thawed, causing the joints to rupture and leading to the displacement of the blocks. Until the mortar in the joints has set, care should be exercised in placing loads on the arch. Precautions should also be taken to prevent the bottoms of the tile from becoming stained, as the moisture in the mortar, unless thoroughly dried out, carries down dirt and causes discoloration of the ceiling. It is advisable to apply some waterproof material to the under side of the arches before laying the plaster on them.

22. Size of Blocks for Arches.—Terra-cotta blocks are usually made the same depth as the steel beams, and as they extend about 1½ inches below the lower flange of the

TABLE I

WEIGHT OF POROUS TERRA-COTTA FLAT-ARCH FLOOR CONSTRUCTION

Depth of Arch Inches	Weight Pounds per Square Foot		Allowable Span Between Beams							
			Side Construction				End Construction			
			Arch Set Flat		Arch Set With Slight Camber		Arch Set Flat		Arch Set With Slight Camber	
	Side Construction	End Construction	Feet	Inches	Feet	Inches	Feet	Inches	Feet	Inches
6	24 to 26	20 to 25	4	0	4	6	4	6	5	0
7	26 to 28	22 to 26	4	6	5	6	5	0	5	9
8	27 to 32	24 to 30	5	0	6	0	5	6	6	6
9	29 to 36	26 to 34	5	6	7	0	6	0	7	0
10	33 to 38	28 to 36	6	6	7	6	6	6	7	6
12	37 to 44	30 to 40	7	0	8	6	7	6	9	0
15		37 to 50					9	0	10	0

beams, the upper surface of the flat arch is about 1½ inches below the top flange. The present building laws in New York City require that hollow tile for arches have a depth of 1¾ inches for each foot of span of the arch. The camber in flat arches is very slight and never over ⅛ inch per foot in span.

23. Weight of Arches.—The weight of arches varies with the depth and span. The depth ranges from 6 to 12 inches in arches constructed by the side method, and from 6 to 15 inches in those built by the end method. For office and store buildings, a common depth is 10 inches, the floorbeams being spaced from 5 to 7 feet apart.

The weights of porous tiling are given in Table I, being taken from data furnished by the National Fireproofing Company. It will be noticed that the thicknesses of the arches are less than those allowed in New York City, but the New York laws provide a factor of safety suitable for extreme cases. The quantities given in the table, however, will be found sufficiently strong for ordinary construction.

In calculating the weights of other materials used in floor construction the following figures may be taken: Cinder-concrete filling weighs about 60 pounds per cubic foot; tile, rock, asphalt, or cement finish, about 140 pounds per cubic foot; and wooden sleepers, 28 pounds per cubic foot. Maple flooring 1 inch thick weighs 3½ pounds per square foot, and 1 square foot of plastering, two coats, weighs 5 pounds.

24. Strength of Arches.—The strength of flat-tile arches has been repeatedly tested; an arch constructed by the end method, with a span of 10 feet and a depth of 10 inches, sustained a load of 1,000 pounds per square foot. Table II gives, approximately, the safe allowable load for arches of this construction. In the table, the approximate safe loads of flat arches, as ordinarily constructed, have been deduced from recent experiments. Since the arches are often carelessly set, the margin of safety is greater than would otherwise be necessary.

TABLE II

APPROXIMATE SAFE LOAD ON FLAT-TILE ARCHES, IN POUNDS PER SQUARE FOOT

Depth of Arch Inches	Distance Between Beams				
	4 Feet	5 Feet	6 Feet	7 Feet	8 Feet
6	150	100			
7	200	150			
8	275	175	125		
9	300	200	140		
10	325	225	150	100	
12	400	250	200	125	100

25. Ceilings.—Before plastering the ceiling under flat arches, any inequalities should be filled with mortar, so as to make a flat surface. It is customary to apply two coats of plaster directly to the under side of the arches. If furring is necessary for fastening decorative work, etc., it may consist of either wooden or metal strips, which are attached to the bottom of the arches by bolts and covered with wire lathing.

26. Floors.—In nearly all systems of construction, concrete filling is laid on the tile to level up to the top of the I beams; on the latter are then placed nailing strips, or sleepers, usually 16 inches apart, to which the flooring is fastened. The strips are made of thoroughly seasoned pieces of wood, usually chestnut, about 2 inches thick, 4 inches wide at the bottom, and 2 inches wide at the top. Sometimes, 3″ × 4″ pieces are used, the under side being notched 1 inch, to fit over the upper flange of the beams. A common practice is to allow 3½ inches between the top of the I beams and that of the floor, in order to insert water and gas pipes, electric wiring, etc. The nailing strips are usually laid at right angles to the beams, and are fastened to them by iron clamps, one end of which is hooked under the top flanges, while the other is driven into the side of the strip. If the strips are laid parallel with the beams, pieces of flat iron, about $\frac{1}{8}$ in. × 2 in. and 1 foot long, are nailed across the under side of the strips, about 4 feet apart, to hold them firmly in place. When the sleepers are laid, concrete is filled in between them to within $\frac{1}{4}$ inch of the top, the beveled sides of the strips holding them in position.

27. As lightness is of prime importance in floor construction, the concrete should weigh as little as is possible for good work. This result may be obtained by using some light, porous material, such as cinders, etc., in place of broken stone. The cinders, free from dirt, should be mixed with cement or lime mortar, and the concrete should be laid compactly on the arches, being allowed to dry before the flooring is laid. To save the time required for drying, the cinders are often put on dry, but this is a practice not to be recommended. When the beams are very deep, shallow, specially made ∩-shaped tile, as shown at *e*, Fig. 8, are sometimes used for filling.

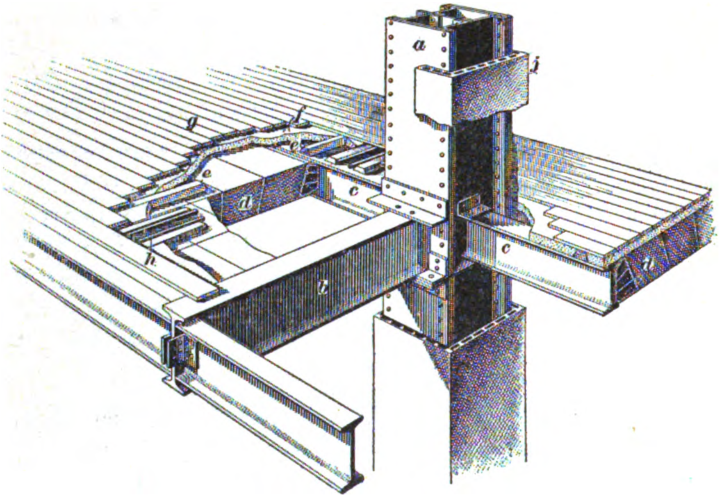


Fig. 11

Office buildings frequently have a great many movable partitions, to suit the requirements of tenants. In such cases, the wooden floors are laid over the whole floor space, and the partitions placed on them; but, if the partitions are to be permanent, they should be put in position before the floors are laid.

28. Fig. 11 well illustrates the foregoing descriptions. At *a* is shown the steel column, formed of **Z** bars and plates and carrying the girder *b* and the floorbeams *c*; at *d* are the tile arch blocks; at *e*, the 2″ × 4″ nailing strips; at *f*, the concrete filling; at *g*, the wooden flooring; at *h*, the water and gas pipes; and at *j*, the tile fireproofing and plastering around the column.

ARCHES OF SPECIAL CONSTRUCTION

29. Herculean Flat Arches.—The **Herculean arch,** shown in Fig. 12, is an improved type of end construction in which no skewbacks are required, while the arch rests on supporting walls at the ends. There is no kick to this arch as there is to the ordinary terra-cotta arch, and, in laying, the joints in the consecutive courses are broken. The **T** irons *a*, *a* are thoroughly embedded in cement mortar, and, being thus encased in a covering of terra cotta and cement 2 inches thick, they are protected from all possible damage by fire. Herculean arches are used in office buildings, libraries, and similar structures, and are usually built on a span of about

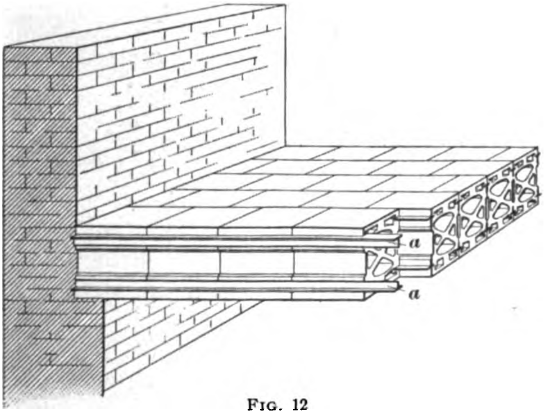


FIG. 12

20 feet. This type of construction is from 8 to 12 inches thick, and weighs from 33 to 51 pounds per square foot.

30. New York Arch.—In Fig. 13 is shown another patent arch somewhat similar to the Herculean flat arch.

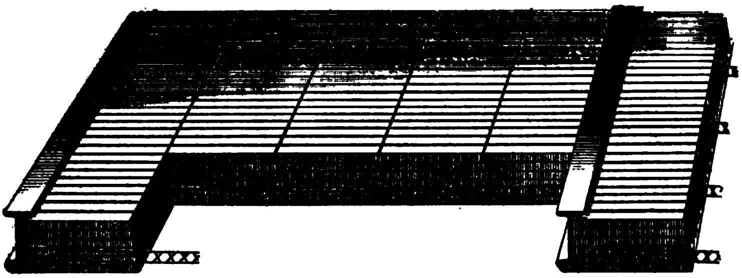


FIG. 13

It is known as the **New York arch,** and is manufactured by the National Fireproofing Company. Instead of employing T irons, the arch is supported by a wire-truss reinforcement, a detail of which is shown in Fig. 14. This arch is

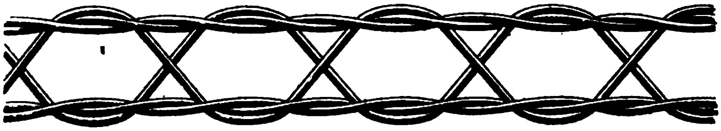


FIG. 14

noted for its lightness, and as a rule is used in construction where the floor loads are light, although on proper spans it may be employed in heavier construction.

SEGMENTAL TILE ARCHES

31. Segmental tile arches of the forms shown in Figs. 15 and 16 are frequently used in warehouses, the plaster being applied directly to the under side of the blocks or to expanded metal or wire lath secured to the beams. The bottom flanges of the beams are protected either by plaster laid on wire lathing or by properly shaped skewbacks. This kind of arch makes a very strong floor, and is much cheaper than a flat-tile arch. Segmental arches have been built in spans up to 20 feet, thus saving considerable weight in the columns and beams, as in such cases many of the latter, which would otherwise be required for short spans, may be omitted.

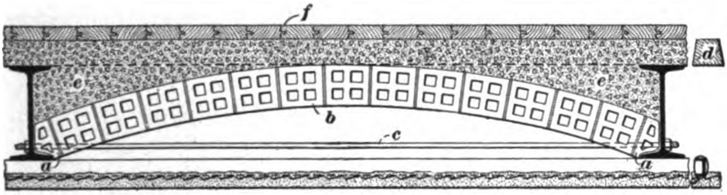


FIG. 15

The tile used for segmental arches may be either dense or porous; the latter is lighter and equally as strong as the former, and, consequently, is preferable to the dense tile.

32. Common Segmental Tile Arch.—The ordinary segmental tile arch consists of blocks from 4 to 8 inches deep and about 1 foot long, the rows being laid with joints broken longitudinally. The rise of such arches should be about one-eighth of the span if possible, and, in any case, not less than one-twelfth.

Fig. 15 shows a common segmental tile arch, *a* indicating the skewbacks, *b* the hollow inside blocks, and *c* the tie-rod taking up the thrust of the arch. This tie-rod should be placed near the lower flanges of the beams, and should be well protected by special tiling or by metal lathing and plaster. At *e* is shown the concrete filling; at *d*, the nailing strip; and at *f*, the flooring.

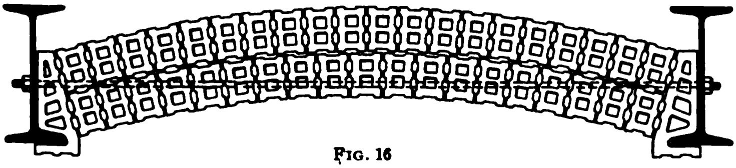


FIG. 16

33. Hollow-Brick Segmental Arch.—In Fig. 16 is shown a **hollow-brick arch** as made by the National Fireproofing Company. This arch is turned with two rowlocks instead of one, and is therefore very strong. The skewbacks are arranged to protect the bottom flanges of the **I** beams, and the tie-rods are raised up high enough to be covered by the terra cotta.

34. Weight of Segmental Arches.—The weight per square foot of single-rowlock segmental tile arches, exclusive of concrete and plastering, is about as given in Table III.

TABLE III

WEIGHT OF SEGMENTAL ARCHES

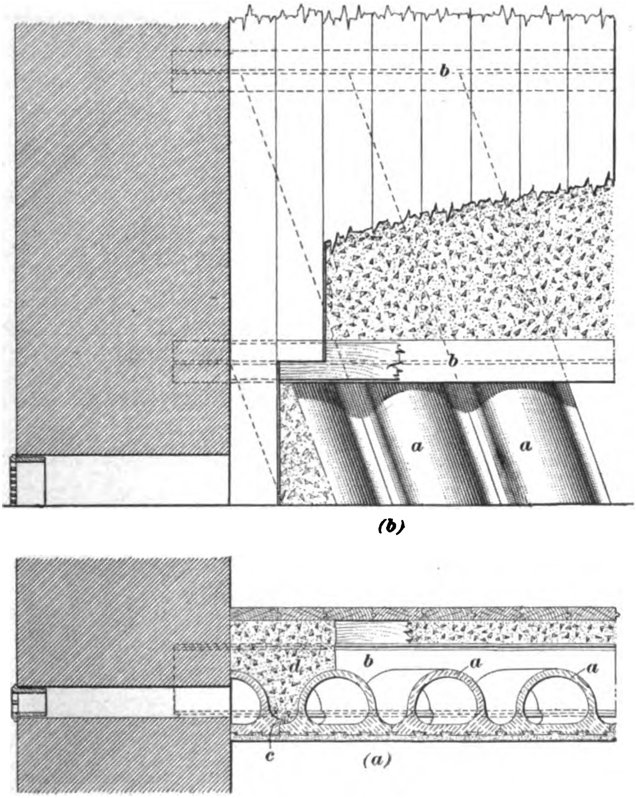
Depth of Tile Inches	Safe Span Feet	Weight Pounds per Square Foot
4	8	20
6	16	30
8	20	40

35. Strength of Segmental Tile Arches.—The strength of properly constructed segmental tile arches is practically only limited by the safe load for the beams. A porous-tile arch with a 15-foot span and a 16-inch rise, and constructed of 6-inch blocks for the central 7 feet 8 inches and 8-inch blocks for the remainder, was loaded on one side by placing bricks on it; when the weight reached 1,235 pounds per square foot, the unloaded portion buckled and collapsed. A common brick arch with a span of 8 feet, a rise of 10 inches, and a depth of 5½ inches, failed by buckling under an eccentric load of 885 pounds per square foot.

36. Setting Segmental Tile Arches.—Segmental tile arches are laid in the same way as flat arches, with the exception that the wood centers are suspended on hooks from the beams, and can be raised or lowered by nuts threaded on the lower end of the hook rods.

THE FAWCETT SYSTEM

37. The **Fawcett system** of fireproofing bears a similarity to all systems using lintels as a means of carrying the floor construction between the steel girders, or beams. This system, however, is distinguishable from all other systems of fireproof-floor construction in that it assumes to provide a circulation of air around the steel beams, which is intended to protect them from the heat of a conflagration.



(b)

(a)

FIG. 17

The Fawcett system, as shown in Fig. 17, consists of hollow terra-cotta lintels supported on the lower flange of the steel floorbeams. These lintels *a*, which have the cross-section shown in (*a*), are placed in such a manner that their shortest diagonal *b b* in (*b*) is at right angles to the web of the steel beams. Since the tiles are laid in this manner, a special tile is needed at the end of each bay. This tile, shown in section in (*a*), consists of the ordinary form of tile cut on the diagonal in the molding, and is called a *split tile.* It is provided with a lip *c* that rests on the adjacent lintel, and the lower part of the tile has dovetailed grooves so as to give a key, or clinch, to the plaster.

38. The tiles are composed of dense terra cotta or pipe clay molded to form, and are burned to a considerable degree of hardness, so as to obtain the required transverse strength. After they are laid in position between the steel beams, concrete is tamped on top of them, as shown at *d*, Fig. 17 (*a*).

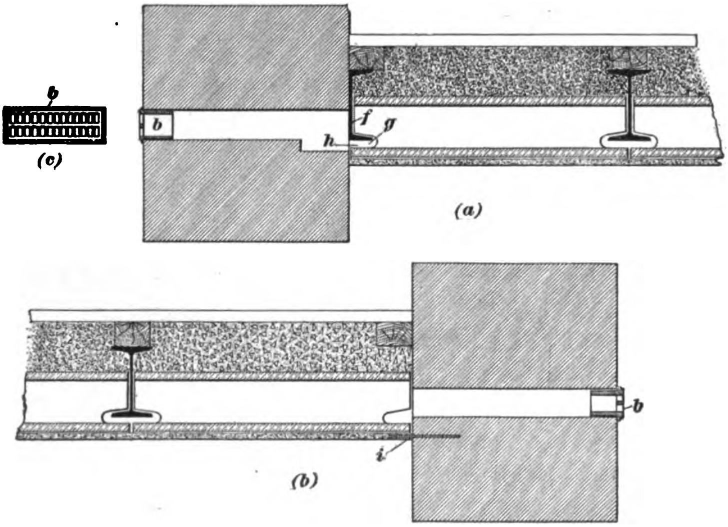


Fig. 18

The concrete takes a bearing on the lower flanges of the steel floorbeams and consequently carries the entire load of the floor, while the tile merely acts as a permanent centering, which, being hollow and provided with air spaces, forms an admirable fire-resisting medium, besides lightening the floor construction to a great extent. The principal purpose of the tubular tile is to provide a circulation of cold air around the steel beams, which is done by introducing in the wall a hollow block *b*, Fig. 18. This block is simply an iron thimble, or box, provided with a grating to prevent clogging with dust or rubbish or the entrance of birds. The cold air from the outside circulates through this opening and through the tubular tiles, as shown in (*a*) and (*b*), passing through the various tiles and along the entire length of the lower flange of the steel beam through the openings *g* in the ends of the tile lintels.

Where the ends of the tiles abut a wall, a steel channel *f* must be used as a support, as shown in Fig. 18 (*a*). Care should be taken, in such a case, that the channels do not entirely close up the ventilation flues, the opening of which must be dropped somewhat, as shown at *h*. The use of a channel may be obviated by building into the brickwork a ¼″ × 6″ plate *i*, as shown in (*b*), which should project a sufficient distance to provide a bearing for the end tiles. At the end of the bay, where the walls run approximately parallel with the length of the tile, no channel or plate is required, for the tile is cut on the diagonal. The end rests on the lower flange of the steel beam and is further supported by the lip resting on the adjacent tile.

FLOORS REINFORCED WITH EXPANDED METAL

39. As expanded metal has already been described in *Cements and Their Uses* and in *Footings and Foundations*, it is merely necessary to state here that this metal can be obtained as thin as No. 27 gauge with ½-inch mesh or less, for light lathing and ceiling work, to No. 4 gauge, 6-inch mesh, for the heaviest construction.

The methods of making floors with concrete and expanded metal are innumerable, and it would be impossible to describe the various designs adopted. They can, however, be divided into two general classes; namely, those *with* ceilings and those *without* ceilings.

40. Floors With Hanging Ceilings.—A method of constructing floors with ceilings is illustrated in Fig. 19 (*a*). As shown in detail in (*b*), the ceiling is supported by light channels, which are held up by means of wire clips fastened around the lower flange of the I beam. The expanded-metal lath is then wired to the channels. As will be noticed, the metal reinforcement in the floor proper is near the bottom of the concrete slab in the center of the span, and near the top of the slab over the supports.

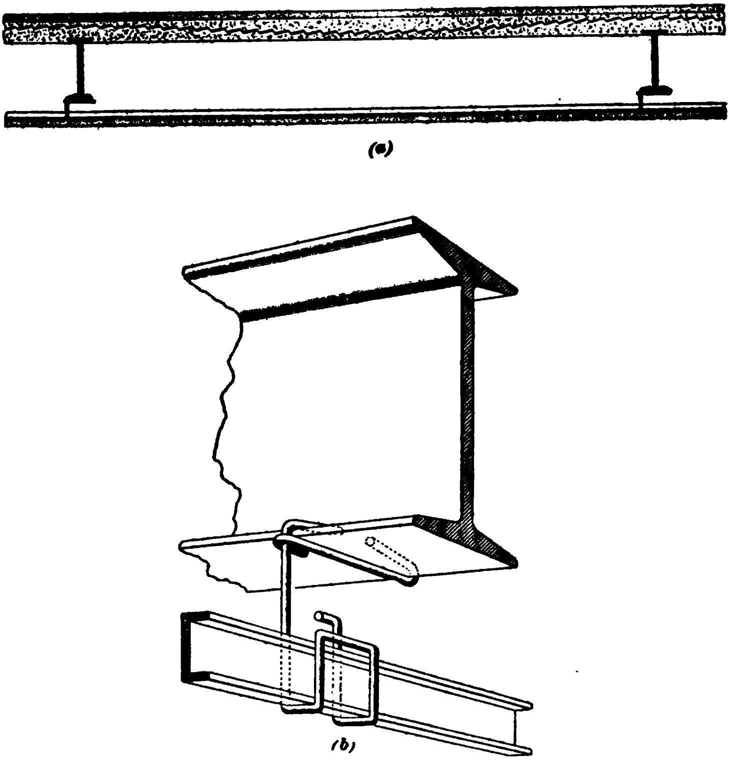


FIG. 19

The illustration shows a floor with a cement finish, but floors of this kind can be made as easily with wood, tile, or any other kind of top surface. In this form of construction, the floor is made first, and while the concrete is setting the floor is supported by a temporary platform. When the concrete is sufficiently hard, the false woodwork is removed, and the ceiling is then suspended and the plaster, either of cement or lime, is put on in the ordinary way. Between the floor and the ceiling is an air space through which may be run water or gas pipes, electric wiring, or ventilating and heating ducts.

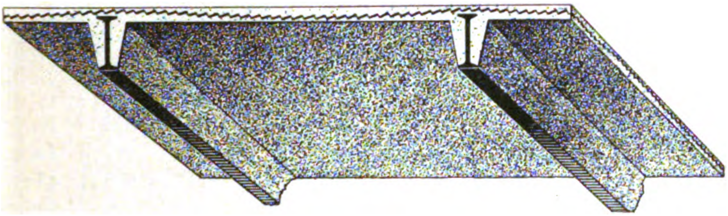


FIG. 20

41. Floors Without Hanging Ceilings.—In Fig. 20 is shown a floor that has no hanging ceiling under it, but the under surface of the floor can be covered with a coat of plaster, while the **I** beams are protected by concrete. This type of floor is suitable for a factory or any building in which the appearance of the ceiling is of no consequence. As can be seen, this floor is extremely simple in construction, and there are no places where dust can accumulate or where vermin can lodge. As shown in the illustration, however, the **I** beams are not properly fireproofed underneath.

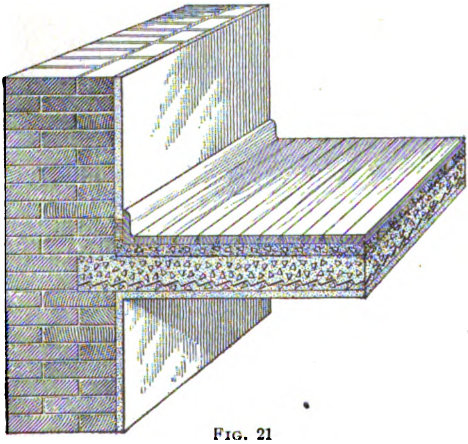


FIG. 21

42. Fig. 21 illustrates a method of supporting a reinforced-concrete floor on the party wall of a building. As will

TABLE IV

BREAKING LOADS OF CONCRETE FLOORS

Type of Floor	Thickness of Slab Inches	Uniform Load per Square Foot, in Pounds						
		4-Foot Span	5-Foot Span	6-Foot Span	7-Foot Span	8-Foot Span	9-Foot Span	10-Foot Span
Cinder Concrete With Expanded Metal of No. 16 Gauge, 2½-Inch Mesh	2	765	460	300				
	2½	1,190	700	465	330			
	3	1,680	1,000	660	468	350		
	3½	2,250	1,350	885	628	468	360	
	4	2,860	1,710	1,130	795	592	458	365
	4½	3,320	1,980	1,300	920	690	530	425
	5	3,720	2,220	1,460	1,040	775	600	480
	5½	4,150	2,480	1,640	1,150	860	665	530
	6	4,550	2,720	1,790	1,270	950	730	582
Cinder Concrete With Expanded Metal of No. 10 Gauge, 3-Inch Mesh	2	820	492	324				
	2½	1,280	768	505	357			
	3	1,820	1,090	715	509	380		
	3½	2,440	1,460	960	680	504	392	
	4	3,130	1,870	1,230	872	650	502	333
	4½	3,880	2,320	1,530	1,080	807	622	413
	5	4,660	2,800	1,840	1,300	975	750	500
	5½	5,440	3,260	2,140	1,520	1,130	875	580
	6	6,000	3,600	2,340	1,680	1,250	960	640
Rock Concrete With Expanded Metal of No. 16 Gauge, 2½-Inch Mesh	2	1,065	638	420				
	2½	1,600	958	630	445	333		
	3	2,210	1,320	870	620	460	355	
	3½	2,720	1,630	1,070	760	565	436	347
	4	3,150	1,890	1,245	878	655	506	403
	4½	3,600	2,150	1,410	1,000	750	576	460
	5	4,040	2,420	1,590	1,120	840	646	516
	5½	4,470	2,670	1,762	1,240	930	716	571
	6	4,900	2,930	1,930	1,375	1,020	786	628
Rock Concrete With Expanded Metal of No. 10 Gauge, 3-Inch Mesh	2	1,165	695	458	324			
	2½	1,790	1,070	710	500	375		
	3	2,500	1,500	984	695	520	402	320
	3½	3,250	1,940	1,280	900	675	522	415
	4	4,100	2,450	1,610	1,140	850	656	522
	4½	4,750	2,840	1,870	1,320	990	763	610
	5	5,320	3,180	2,090	1,480	1,110	854	680
	5½	5,900	3,520	2,320	1,640	1,230	950	755
	6	6,450	3,860	2,530	1,800	1,345	1,040	825

be noticed, the floor is made just the thickness of two bricks and mortar joints, and sets into the wall. Instead of fitting the concrete slab into the wall, however, the brickwork may be corbeled out so as to provide a bearing. As shown in the illustration, the plaster is applied directly to the brickwork, but the wall can be furred and lathed if desired.

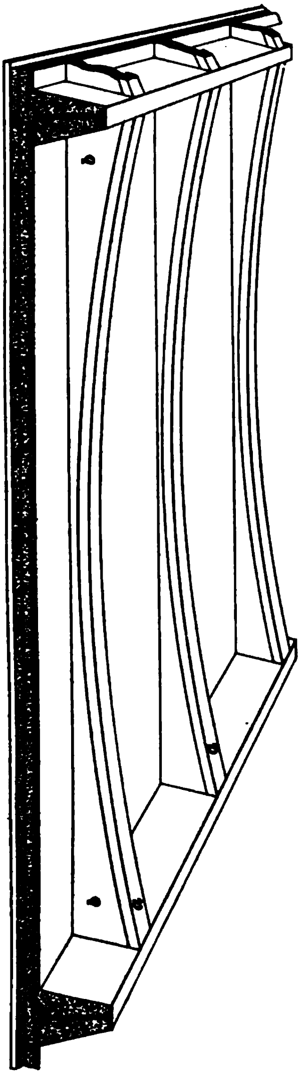


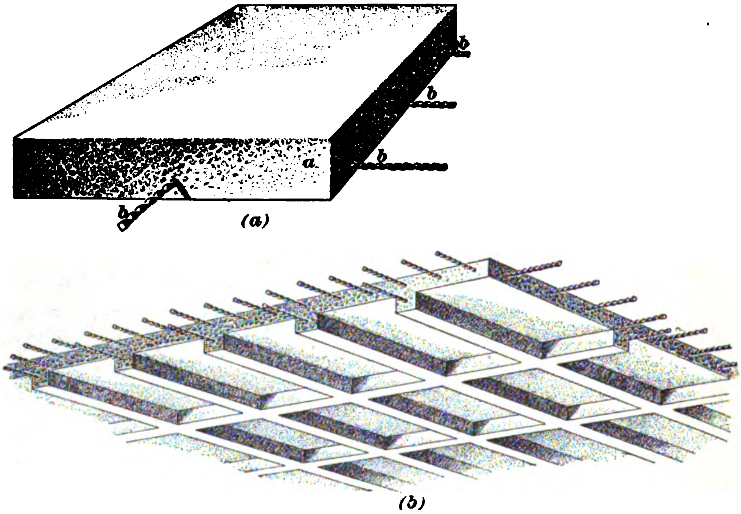
FIG. 22

43. Breaking Loads of Concrete Floors.—Table IV gives the thickness and floor loads for different gauges of expanded metal used in floor construction.

44. The Golding System. The **Golding system** of fireproof-floor construction is shown in Fig. 22, and consists of the usual construction strengthened by the steel channels *a*, *a* sprung between the lower flanges of the beams and having the spandrels *b*, *b* filled with concrete. This system is adapted to long spans and may be used economically for spans of from 8 to 18 feet. For further finish and protection a flat ceiling may be used, but the customary practice is to fireproof the beams and the arched channels separately, thus preserving the ribbed effect and allowing the maximum headroom. The steel channels are usually spaced about 4 feet apart. Their size is governed by practical experience more than by exact calculation. Tie-rods are required in the bays, or panels, and are conveniently placed over the arched channels and laid between their flanges.

CONCRETE FLOORS REINFORCED WITH IRON RODS

45. The Ransome Floor.—Concrete containing iron or steel wires or rods embedded in it is now extensively used for floor construction, and in many respects is equal to tile-arch floors, and besides is cheaper. The earliest form of concrete floor was the *Hyatt system*, in which thin plates of iron, set upright and bound together at short intervals by wires—thus forming a kind of gridiron—were placed in the concrete near the bottom, and rested on the floor beams at both ends.



(a)

(b)

FIG. 23

From the Hyatt floor was developed the **Ransome floor,** the difference being in the use of twisted square bars of iron or steel instead of flat bars set on edge. Owing to the twisting throughout their length, the bars are held firmly in place in the concrete and are as strong as the plates and wires, besides costing much less. These floors have been used without intermediate supports for spans up to about 35 feet, and are remarkably stiff under heavy loads. A floor 15 ft. × 22 ft. was loaded for a month with a weight of over 400 pounds per square foot, and the resulting deflection was only about $\frac{1}{8}$ inch.

In Fig. 23 (*a*) is shown the ordinary Ransome floor, *a* being the concrete and *b* the twisted bars, which are inserted near the bottom of the slab so as to take up the tension. In (*b*) is shown the same system as applied to a paneled floor, which is considerably stronger than the flat form.

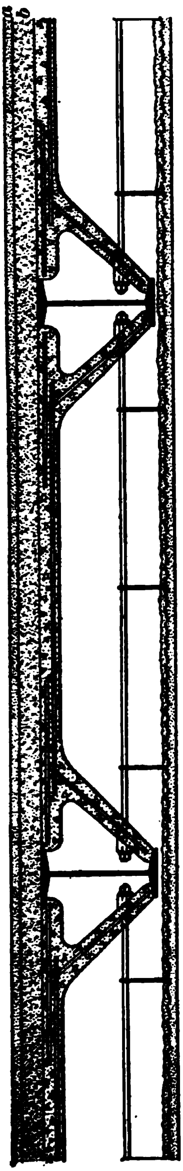


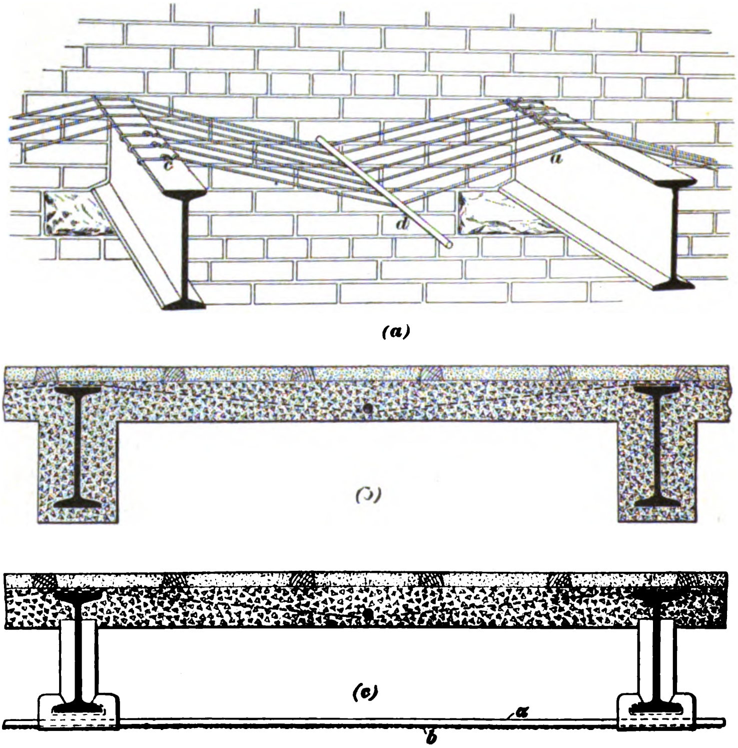
FIG. 24

46. The Thatcher Floor.—Another style of rod floor, designed by the Concrete Steel Engineering Company, is made of Thatcher bars, and has an expanded metal ceiling attached, as shown in Fig. 24. The concrete is formed in suitable molds of any convenient width for handling, usually about 2 feet, and allowed to set, for about a month. Each slab is then dovetailed to the one adjoining and set in place, using cement mortar in the joints. At *a* is shown a granitoid floor, and at *b*, a cinder filling.

Instead of the Ransome or the Thatcher bar, any other patented bar or even a smooth bar may be used for this type of reinforced floor construction, provided, of course, that the design of floor is not patented. A smooth bar will not adhere to the concrete so well as a twisted or corrugated bar, but is cheaper.

CONCRETE FLOORS REINFORCED WITH WIRE

47. The Metropolitan System.—The **Metropolitan system** of fireproof-floor construction is shown in Fig. 25 (*a*), (*b*), and (*c*). In laying the floor, cables—made by twisting together two strands of No. 12 gauge galvanized-iron wire—are secured to the upper flanges of the auxiliary floorbeams at intervals of 1½ inches, as shown at (*a*), in which *a* are the galvanized-wire cables; *c*, the hooks by which the cables are secured to the upper flange; and *d* is a piece of bar, or pipe, laid centrally between the I beams so as to stretch the cables and give them the camber, as shown in (*b*) and (*c*). After the cables are fastened, a composition



(a)

(b)

(c)

FIG. 25

consisting of 1 part of wood shavings and 5 parts of plaster of Paris, mixed to a thin paste with water, is poured in place on temporary wooden centerings. The centering is placed 1 inch below the round iron bars, or pipes, used at the center of the span to stretch the cable. The composition, which hardens quickly, is brought to an even surface about ½ inch above the level of the floorbeams, and when finished forms a reinforced slab about 4½ inches thick, which is ready for laying the sleepers for the finished floor on the top and for applying the plastering beneath. The auxiliary beams, as well as the principal girders, are protected by the same material, which is usually cast in place around the webs and lower flanges, always being so arranged that 2 inches will be the minimum thickness of the fireproofing.

Tie-rods are not required in this system, as the floor loads are transmitted by a suspension system rather than by an arch. The tendency to overturn or twist the I beams is counteracted by the cables in the adjacent panels, while in the end panel the beam can be tied to the walls or structure, or it can be made sufficiently heavy to resist any tendency of this kind. This tendency is also partly offset by the fireproofing material, which acts as a compression member between the upper flanges of the steel beams. In (*b*) is shown the completed flooring with a paneled effect beneath.

When a flat ceiling is desired the construction shown in (*c*) is usually employed. Iron bars are placed on or suspended from the lower flanges of the floorbeams, and on these bars is wired herring-bone, pressed-steel lathing that has been dipped in asphalt. On the lathing, the usual plastered ceiling is applied. In the figure, *a* is one of the supporting bars and *b* the metallic lath.

48. The distinguishing features of the Metropolitan system are the utilization of plaster of Paris or a mixture of plaster of Paris and wood shavings instead of stone or cinder concrete, and the adoption of wire cables instead of iron or steel rods or bars. The principal point of superiority of this system is its extreme lightness; its average weight, without considering the steel floorbeams, is from 18 to 20 pounds per square foot, but where a plaster ceiling is used the weight is increased from 6 to 8 pounds. The transverse strength of the system is ample for any usual floor loads, as actual tests have demonstrated.

ARCH SYSTEM OF REINFORCED CONSTRUCTION

49. The Roebling System.—In the **Roebling system** of construction, which is shown in Fig. 26, the concrete is used as an arch—not as a beam. The first step in this method of construction is to spring an arch of wire cloth between the beams, as shown at *a*, stiffening the cloth at short intervals by steel rods *b* and resting the ends of the arch on the lower flanges of the beams. On this base is laid the arched concrete filling shown at *c*, which, on becoming hard, transmits the loads directly to the beams. The ceiling is held by a similar netting of wire *f*, fastened to stiffening rods *d*, which are attached to the lower flanges of the beams by clamps and also to the arch netting by tie-rods, as at *g*.

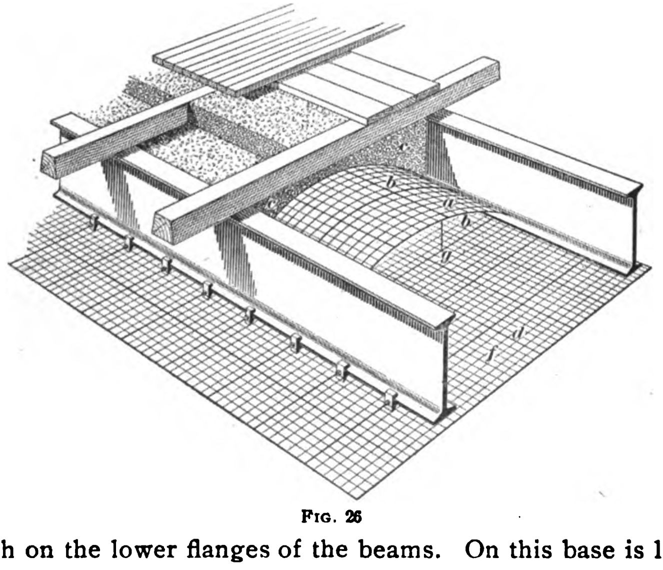


FIG. 26

This floor, exclusive of beams, and not including the ceiling and two thicknesses of wooden flooring, weighs about

50 pounds per square foot, according to the span. The carrying capacity is about 1,500 pounds per square foot on spans of from 4½ to 5 feet.

The Roebling segmental-arch floor possesses the following advantages: (1) a flat ceiling; (2) a continuous air space between the floor arch and the ceiling; (3) ease of adaptation to any building or any load; and (4) no wooden centerings are necessary, as the wire arches form the support for the concrete during the laying.

FLAT ARCHES OF REINFORCED CONCRETE

50. The Roebling Flat Arch.—The **flat system of construction,** involving the use of bar iron to reinforce the concrete and of woven-wire lathing to supply a permanent centering, has been designed to meet the requirements for a light, low-priced floor adapted to a wide spacing of the beams. The Roebling flat system of construction is shown in detail in Fig. 27, and consists of a light iron framework embedded in concrete, forming a monolithic slab. The framework is made of flat iron or steel bars *a* set on edge and spaced 16 inches between centers. The flat bars are given a quarter turn at both ends so that they will lie flat on the top flange of the steel beams supporting the floor system, and the turned ends form a hook, or clamp, that securely attaches them to the upper flange, thus obviating the necessity of tie-rods. These pieces of bar iron are held in position, laterally, by flat or half-round iron spacers that have a hook *b* turned on each end. The spacers are placed at suitable intervals to

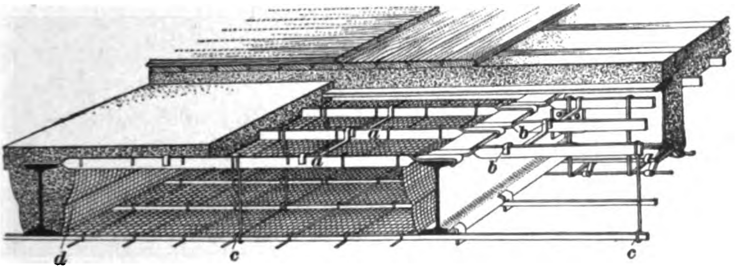


FIG. 27

separate and brace the bars. The **woven-wire lat** the $\frac{1}{4}$-inch round stiffening ribs woven in every is applied to the under side of the bars, the stiffe being run crosswise over the bars and laced to then intersection. On the wire lathing supported in this cinder concrete is deposited, thoroughly embedding ironwork.

51. The ceiling used in conjunction with this sy construction is the same as that employed with the ar struction, but as the span is greater in this system, $\frac{3}{4}''$ flat bar iron set on edge is used for the support of the c

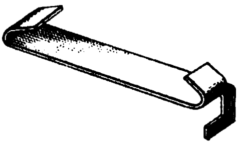


FIG. 28

instead of $\frac{7}{16}$- or $\frac{9}{16}$-inch round bar The flat bars are clamped to the l flange of the I beam by means wrought-iron clip, which is show detail in Fig. 28. When the span is c 8 feet, the ceiling is supported wire *c*, *c*, Fig. 27, suspended from the rods that form the t sion members in the floor system. The I beams in this cc struction are protected by means of concrete filling, which held in position by the upper and lower flanges and t woven-wire lathing placed as shown at *d*.

THE COLUMBIAN SYSTEM

52. The **Columbian system** consists of concrete slabs reinforced and supported in position by special rolled steel bars, which usually have the sectional form shown in Fig. 29. These bars are either framed to the steel beams, as shown at *b*, Fig. 30 (*a*), or they are supported by special clips, or stirrups *c*, hung over the top flange of the steel beam, as in (*b*). The stirrup is shown in detail in Fig. 31. Under the steel bars is placed a wooden center on which the concrete filling is tamped. When the concrete has set, it forms practically a stone slab strengthened by the light steel beams that are thoroughly protected by the concrete. Any character of finished floor can be used on it.

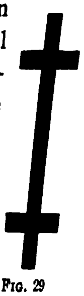


FIG. 29

The paneled-ceiling treatment is shown in Fig. 32, but where a flat ceiling is required, the construction shown in Fig. 33 is employed.

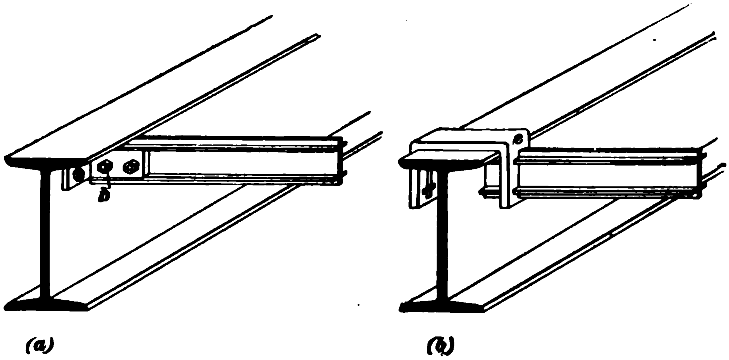


FIG. 30

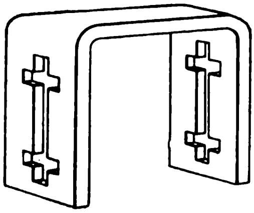


FIG. 31

53. In the construction shown in Fig. 33, which is known as **double construction,** the floor system is practically the same as in Fig. 32, except that the concrete around the steel beam is omitted, as the suspended ceiling furnishes the desired protection. The ceiling is constructed in the same manner as the floor; that is, special rolled bars are supported on the lower flanges of the I beams and are embedded in a thin layer

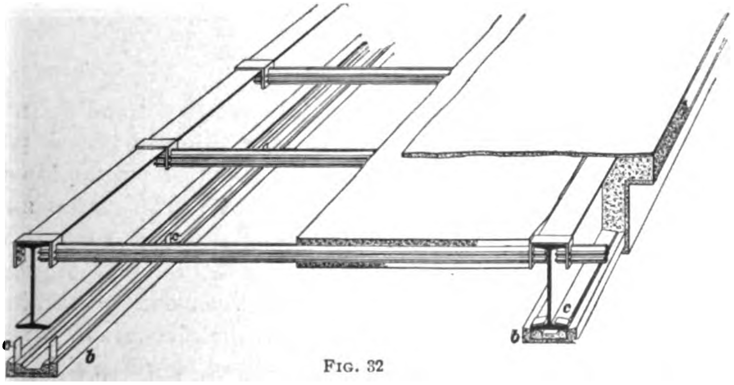


FIG. 32

of concrete, which they support. The finished ceiling is formed by plastering the bottom surface of the concrete slab.

In the construction shown in Fig. 32, the principal beams or girders are protected by a specially molded concrete slab *b*, so arranged as to provide an air space at the lower flange of the girder—thus furnishing additional fire protection—and having embedded in it iron anchors *c* to fasten it in place. This special slab is shown detached below the left-hand I beam in Fig. 32, and in place at the right-hand beam. The embedded anchors at *c* are turned over the lower flange of the girder and hold the slab in position.

54. Centering for Columbian System.—All types of the Columbian system require a temporary wooden centering to support the concrete until it has set. This centering is usually built as shown in Fig. 33, which shows the method employed in the construction of the floor system and the flat ceiling beneath. The centering for the ceiling, which is put up first, is supported on the stringers *a* hung from the lower flange of the steel girder by the wrought-iron clamp and hanger *b*. When the steel bars forming the main support of the ceiling are in position, concrete *c* is dumped on this centering and tamped in place. After the concrete forming the ceiling has obtained its initial set, the sleepers *d*, which carry the wooden supports for the centering on which the floor in constructed, are put in place. The centering for the construction of the floor is removed through openings

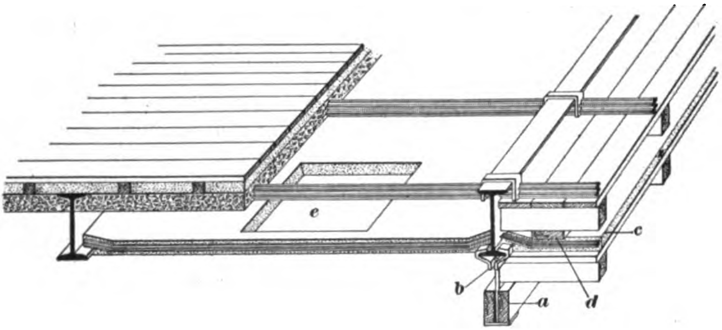


Fig. 33

provided at intervals in the concrete ceiling, the openings being closed afterwards with a concrete slab. In Fig. 33, *e* shows one of these openings, which is rectangular and is provided with beveled sides so that the concrete slab can be introduced through it and, on being lowered into place, make a tight and secure ceiling.

55. Spacing of Girders.—The most economical arrangement for the Columbian floor system is to place the steel girders from 7 to 8 feet apart for the panel construction shown in Fig. 32, and from 6 to 7 feet for the double construction shown in Fig. 33. If the spans are increased beyond these limits, there is little saving by using this system of construction, as the ordinary I beams rolled by the mill can be economically substituted for the special sections.

The span recommended for the Columbian system is from 6 to 7 feet, and the steel girders should be arranged for the construction at these distances. The concrete used is composed of Portland cement, sharp sand, and crushed furnace slag or broken-stone screenings, although for light floors, cinder concrete is commonly used.

TABLE V

WEIGHT PER SQUARE FOOT OF COLUMBIAN SYSTEMS

Style of Ceiling	Size of Steel Bars Inches	Weight of Floor and Ceiling	
		Stone Concrete Pounds	Cinder Concrete Pounds
Paneled . . .	1	43.5	22.7
Paneled . . .	2	47.4	24.8
Paneled . . .	2½	55.6	30.4
Flat	1	50.0	31.7
Flat	2	55.1	34.7
Flat	2½	61.3	37.3

NOTE.—Exclusive of the beams, for the weight of the fill between the sleepers, or wooden floor, add 6 pounds per square foot per inch thickness of fill.

56. Weight of Columbian Systems.—The weights of the Columbian system for the several sizes of bars and the different types of construction are given in Table V. In compiling this table, the weight of the stone or slag concrete was assumed to be 140 pounds per cubic foot, while the weight of the cinder concrete was taken at 72 pounds.

THE RAPP SYSTEM

57. The method of construction shown in Fig. 34 is known as the **Rapp system** of fireproof-floor construction, and while the several types of this system differ from one another in detail, they are practically the same in their main features. The distinguishing feature of this method, however, is the special arched **T** bars *a* sprung between the lower flanges of the steel floorbeams. These bars are formed of sheet metal about $\frac{1}{4}$ inch thick, and are spaced about $8\frac{1}{4}$ inches from center to center, so that a brick will set neatly between the vertical legs of the **T**'s, which are held in place during erection by the bar-iron separators *b*. When the **T** irons are in place, the brick *c* are laid on edge and wedged with slate, the joints then being grouted. The brick supported by the **T** bars form a permanent centering, on which is deposited the concrete filling *d*. The sleepers *e* are laid perpendicular to the steel beams, and are held in place by concrete filling.

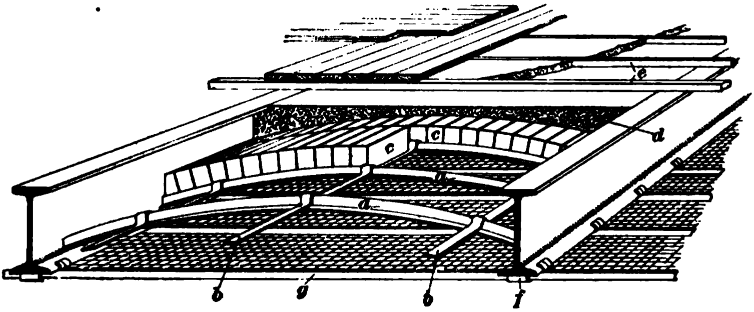


FIG. 34

The Rapp ceiling is put in place without the use of temporary centerings, and, when a flat ceiling is required, it is put in place on wire lathing secured to bar-iron supports *g*, which are clamped to the lower flanges of the **I** beams, as shown at *f*.

58. The Rapp system of fireproofing is adapted to many types of buildings, while the principle of supporting bricks, fireproof tile, or slabs of fireproofing material between **T** irons is applicable to many situations, and can be employed in the construction of roofs and domes. The floor is rapidly put in place, and owing to the fact that the simplest materials are employed, delays in construction are not likely to occur.

The weight of the Rapp floor varies from about 40 to 60 pounds per square foot, according to the depth of the beams used as supports.

STEEL-PLATE SYSTEMS

59. There are several systems of fireproof-floor construction that employ bent, crimped, or corrugated steel plate as the supporting medium between the steel beams. The plate, however, will not stand great heat, and unless these systems are protected beneath by a suspended ceiling, they are not satisfactory. Furthermore, the moisture in the warm air of the room underneath condenses on the steel plate to such an extent as to cause water of condensation to drip, which is not only liable to damage any goods in the room, but also corrodes the plates.

60. Corrugated-Steel Arches.—The **corrugated-steel arch**, which is the simplest of the steel-plate systems, is shown in Fig. 35. This arch consists of corrugated sheet iron of No. 16 gauge, bent or sprung between the lower flanges of the steel floorbeams, as shown at *a*. The corrugated sheet bent in this way possesses great strength, and not only assists in supporting the floor load but acts as a center on which the concrete *b* may be dumped and tamped. Any finished floor may be laid on the concrete.

Tie-rods between the steel beams are not necessary where the arches are placed side by side and where the thrusts counteract each other. However, they should be used to hold the beams from any side deflection during construction. When tie-rods are used, they should lie in a corrugation, so as

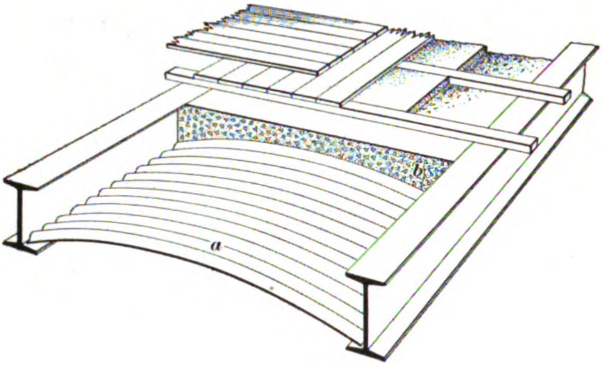


Fig. 35

to enter the steel beams as near the lower flange as possible. The weight of such a floor is from 25 to 40 pounds per square foot.

61. Multiplex Steel-Plate Floors.—The **multiplex steel-plate floor construction**, shown in Fig. 36, consists of a plate *a*, bent as shown, that rests on the steel floorbeams

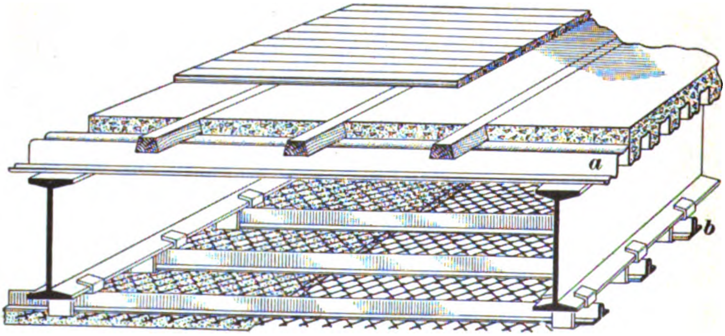


Fig. 36

and provides a means of supporting the concrete and the floor load. This sheet steel is usually galvanized to protect it from corrosion, which is likely to occur in this type of construction. The ends of the plates are sometimes anchored to the top flange of the steel **I** beams by driving a $\frac{3}{16}$-inch rod through the plates and turning it around the flange of the beams.

Where a flat ceiling is desired, it is suspended by the usual means and the plaster is supported on woven-wire lathing. In this construction, the lathing is carried on special pressed-steel furring strips *b*.

SELECTION OF A FIREPROOF SYSTEM

62. The question of choosing the best floor system out of the many of nearly equal merit hinges largely on the cost, as any of those that have been described will be found amply strong and, as a rule, entirely fireproof, if properly constructed. Although, perhaps, the greater number of architects prefer the use of arch tile floors, the combinations of concrete and steel are much used. Such floors have passed through the experimental stage and have shown that they make a very strong and thoroughly fireproof construction. Other things being equal, the floor that is lightest is the best, as the weight and size of beams, girders, columns, etc. may then be considerably lessened, which is an important factor in the cost of the structure. Where strength is the object sought, those floors should be used which have shown sufficient strength to meet the requirements of the case. In all floors, the character of the workmanship and the quality of the materials used have a great deal to do with the durability and efficiency, and hence should receive careful attention during construction.

CONSTRUCTION OF FIREPROOF ROOFS

TERRA-COTTA ROOFS

63. Flat Roofs.—The roof of a fireproof building is usually flat, with a pitch of from ¼ to ½ inch to the foot. The advantages of a flat roof are the ease with which it can be made fireproof, and the smaller cost as compared with pitch roofs. The roof is built in the same manner as tile floors, the tiling being carried on light **T** or **I** beams, and the supporting columns having a lighter section than those under the floors.

When the tile or other material forming the bearing surface is in place, it should be plastered over with cement mortar, to give it an even face, ready for the exterior covering. The latter may be either of tile set in cement or of tar and gravel, asphalt, copper, iron, or tin. The use of porous tile, into which nails may be readily driven, is recommended when copper or tin coverings are to be used.

A very essential point in roof construction is that the bottom flanges of all **I** or **T** beams be completely enclosed by fireproof materials. When tiling is used, a heavy coat of plastering should be placed on it, especially under the beams. All supporting girders and columns should also be well protected, either by hollow tiling or by plastering on metal lathing.

64. Mansard and Pitch Roofs.—For mansard and other roofs having a very steep pitch, the usual construction consists of **I** beams set from 5 to 7 feet apart, the intervening spaces being filled with 3-inch hollow partition tile. If slate is to be used as a covering, nailing strips are fastened to the tile and the surface is brought up flush with cement mortar, on which the slate is laid. The strips are unnecessary, of course, if porous tiling is used. For roofs having less than 45° pitch, plates of porous tile supported on 3″ × 3″ **T** beams are very satisfactory. All parts of the ironwork should be well protected from fire by casing them in porous tiling or in wire lathing covered with a thick coating of plaster. A roof of this kind weighs about 20 pounds per square foot.

65. Ceilings.—Ceilings under flat roofs are usually similar in construction to those beneath the floors, but all parts are made quite light. Under pitched roofs, however, when a flat surface is necessary, the ceiling is usually suspended by rods attached to the roof framing. These rods carry angles or **T** bars, to which is fastened the wire netting holding the plaster. Such ceilings weigh about 12 pounds per square foot, exclusive of iron.

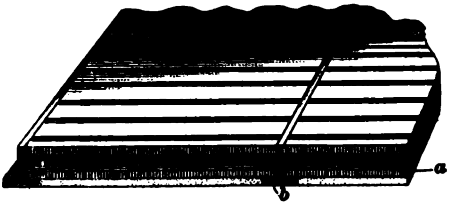


Fig. 37

Sometimes light tiling similar to roof tiling is used instead of the metal lathing, in which case the porous variety is the best. In Fig. 37 is shown a ceiling, constructed by the National Fireproofing Company, with porous tile *a* carried on **T** bars *b*. The tiles are from 2 to 3 inches thick, from 16 to 24 inches long, and weigh from 11 to 15 pounds per square foot, not including plastering. Fig. 38 shows a ceiling made of hollow tile laid on **T** bars, with plates to protect the flanges.

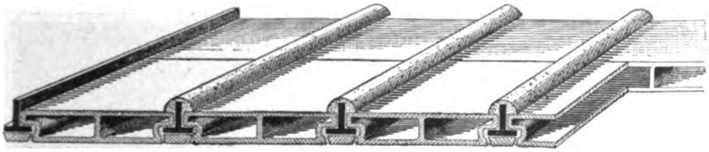


Fig. 38

EXPANDED-METAL ROOFS

66. A system of fireproof-roof construction that grows more important from year to year is **expanded-metal concrete construction.** Although rods can be used instead of expanded metal, as has been explained in floor work, yet either expanded metal or wire lath seems best adapted for the purpose.

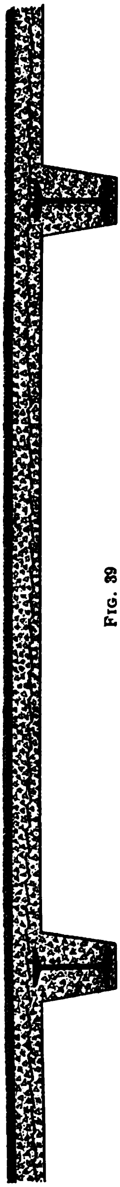


FIG. 39

An expanded-metal flat roof is made similar to an expanded-metal floor, except that a lighter metal is used and the construction is not so thick, because the roof is not required to carry so much weight. Fig. 39 illustrates the construction of such a roof. As concrete in itself is not entirely waterproof, the usual custom is to cover the roof with some good roofing material, such as tar and gravel, as shown in the illustration. In order to give a better bond to the concrete used to fireproof the beams, expanded metal is placed around the bottom flange of the I-beam rafters.

67. Fig. 40 shows the application of an expanded-metal roof to a steel roof truss. This roof is protected on the outside by slates, which are nailed to the concrete. Purlins have been dispensed with in the construction shown in the illustration, and the concrete slab is placed directly on the common rafters and spans from truss to truss. Purlins are sometimes used, however, in which case they should be bedded in the concrete.

68. Ceiling Construction.—Although the roof construction shown in Fig. 40 is fireproof from the outside, it would in no way protect the steel truss underneath from destruction should fire occur on the inside of the building. Therefore, when the truss is to be protected from this direction, a ceiling must be placed below it. Such a ceiling, shown in Fig. 41, is hung from the chords of each truss, as at *a*, and is supported by metal straps *b*, which are secured at their lower extremities to angles *c* running at right angles to the roof trusses. Immediately underneath angles *c* are fastened small channels *d*, running perpendicular to the angles *c*, being held in place by ½-inch malleable-iron

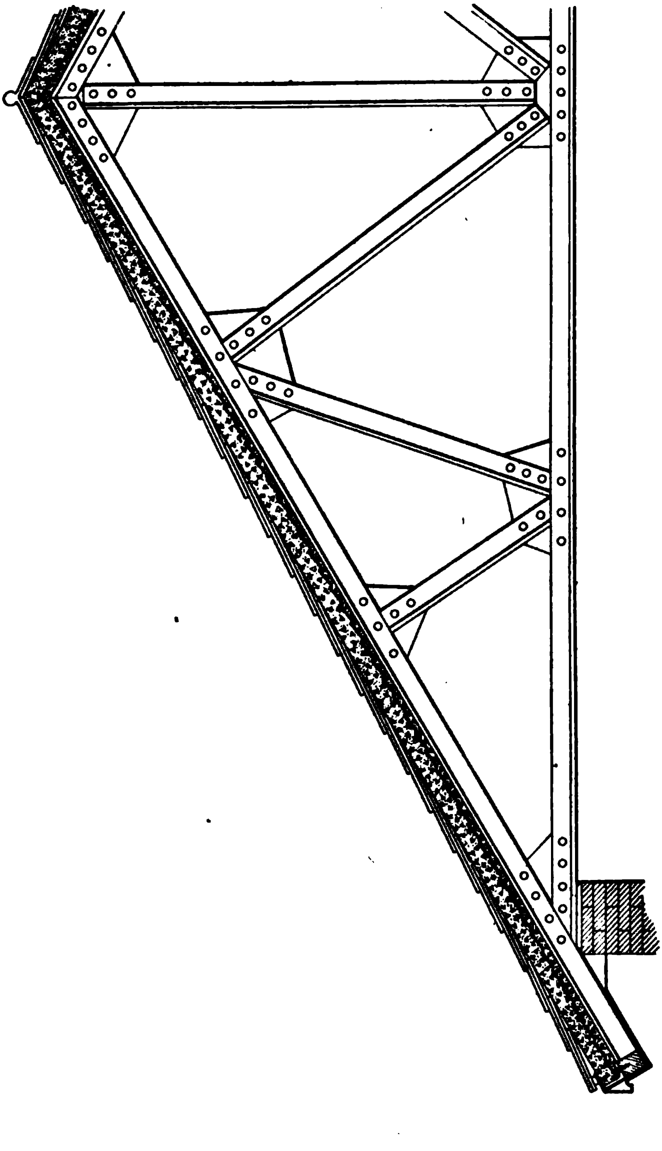


FIG. 40

hooks *e*, a detail of which is shown in Fig. 41 (*b*). The expanded metal is fastened to these channels by No. 19 annealed wire, and the cement plaster is applied the same as on ordinary lath.

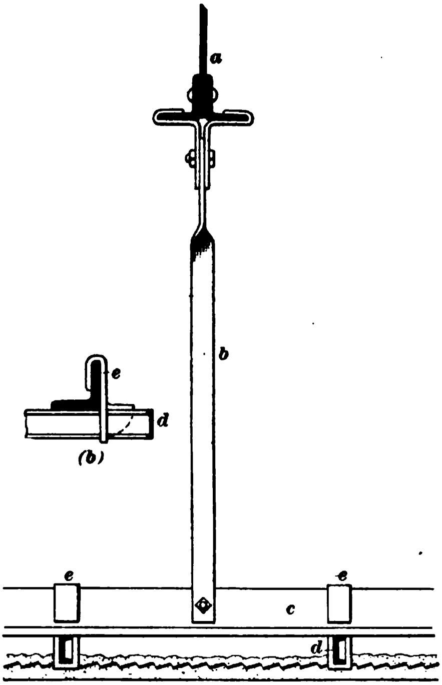


FIG. 41

69. Walls and Cornices on Flat Roofs.—When flat concrete roofs are used, it is often desirable to construct the parapet wall and the cornice and perhaps even the building wall with expanded metal. Fig. 42 shows a detail of such a construction. In a design like this, the roof is built first and the cornice and parapet wall are put on afterwards. A building constructed in this manner is entirely fireproof, and represents one of the foremost types of modern fireproof construction.

FIREPROOF PARTITIONS

TERRA-COTTA PARTITIONS

70. Fireproof partitions are constructed of either brick, hollow terra-cotta tile, or metallic lath and plaster. Brick partitions are too heavy for office-building work, and as they must necessarily be from 8 inches to 1 foot thick, they take up too much floor space. They also offer the objection that they cannot readily be removed to suit the

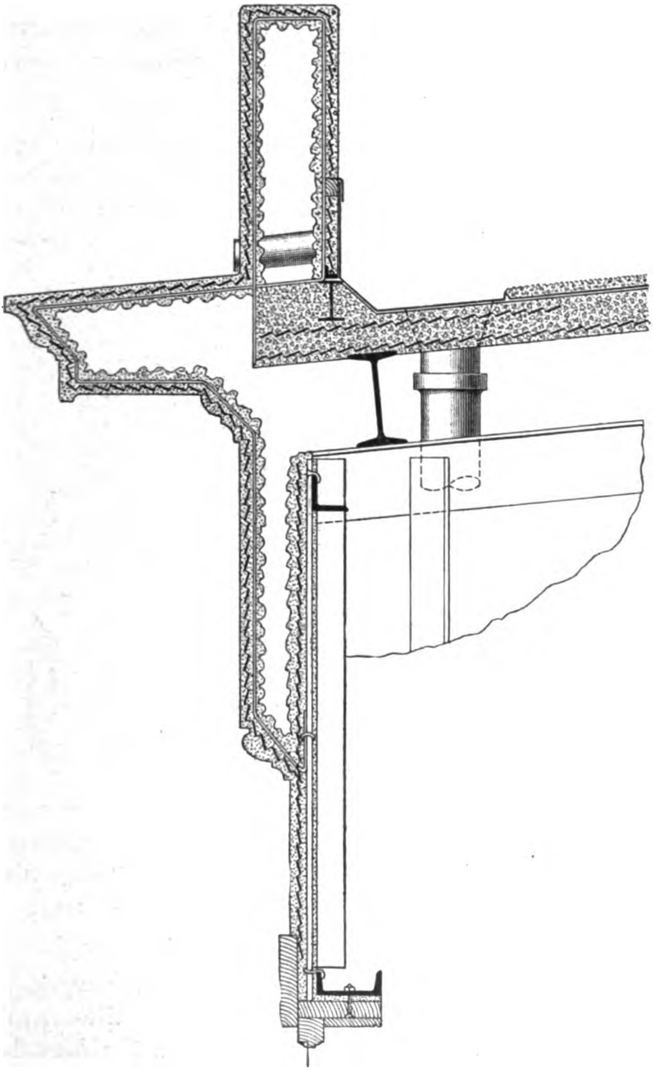


FIG. 42

requirements of the tenants. The use of hollow terra-cotta tile obviates, to a great extent, all of these difficulties, and, when properly laid, provides a light and refractory partition that may be located at any position on the floor and can be readily removed.

71. The usual **terra-cotta tile partition** is shown in Fig. 43. Pipe chases are readily provided by the use of recessed hollow tiles *a*, *a*. The other tiles are also hollow, but the spaces usually run horizontally. As a rule, the blocks

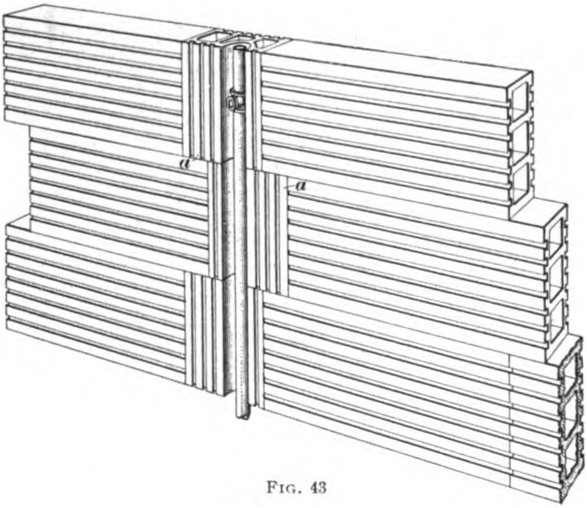


FIG. 43

are set in lime mortar containing about 25 per cent. of cement, and are grooved on the face so as to provide a key for the plaster and thus avoid the necessity of using furring and wooden or metallic lathing. Some quick-setting plaster is generally used for finishing the faces of the tile.

72. Phœnix Tile.—The type of hollow partition tile shown in Fig. 44 is known as the **Phœnix**. The tiles are about 4 inches thick and 12 inches by 18 inches on the face, being hollow and provided with dovetail grooves for plastering, as shown. The lateral stiffness of this tile is greatly increased by the use of flat bands of iron, which fit snugly in grooves *a*, *a* molded along the edges of the blocks. These strengthening bands and partition blocks (4 inches in thickness) have been successfully used for the outside walls of smelting works and refineries. In such positions, they have furnished the strength and resistance of a 12-inch brick wall at considerably less cost.

73. Foundations for Partitions.—In building partitions, the practice of setting terra-cotta tile or any other type of fireproof material on a wooden sill cannot be too strongly condemned. This method of construction has led to considerable fire losses from the burning away of the sill and the ultimate destruction of the partition. The best practice requires that all fireproof partitions rest directly on the concrete of the floor system.

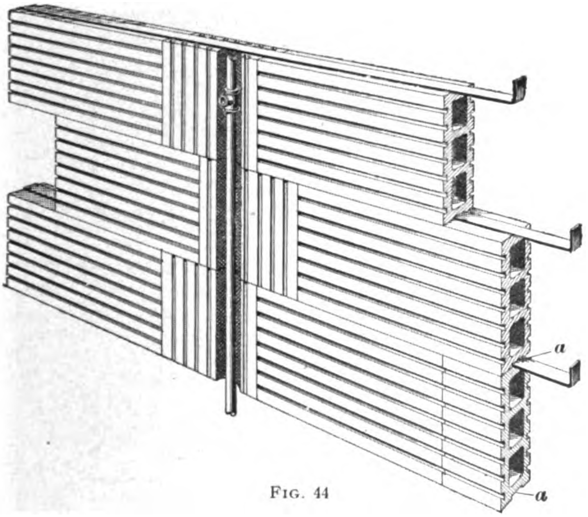
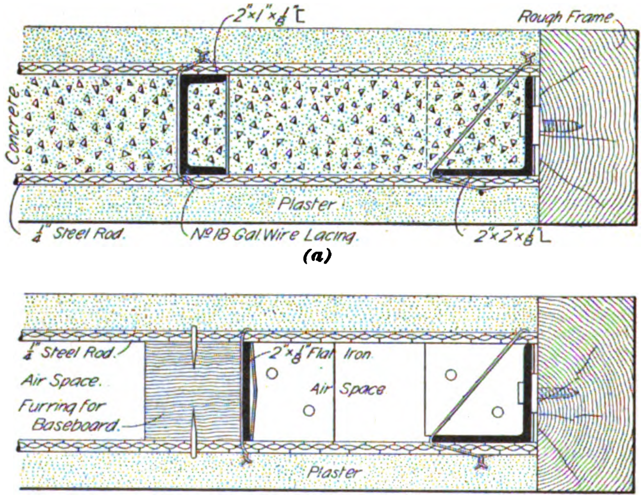


FIG. 44

74. Advantages of Hollow-Tile Partitions.—The hollow clay-tile partition has no particular advantages over other fireproof partitions, but, unlike the ordinary lath-and-plaster partition or the brick wall, it combines considerable strength with lightness and is also entirely vermin proof. The partitions, being hollow, do not readily transmit sound, and being made of a porous, non-conductive material and provided with air spaces, they do not transmit heat, in consequence of which the enclosed rooms are warm in winter and cool in summer. The average weight of hollow-tile partitions, exclusive of plaster, is from 15 to 28 pounds per square foot.

WOVEN-WIRE PARTITIONS

75. Roebling Partitions.—The **Roebling partitions** have all the qualifications of a good fireproof partition. They are somewhat stronger and more elastic than a hollow-tile or block partition of the same thickness, because of their monolithic construction and the consequent absence of any joints. These partitions also have the advantage that pipes and conduits can be placed in any convenient location.



(a)

(b)

FIG. 45

The Roebling system provides either a *solid* or a *hollow partition*, as may be desired. The construction of the solid partition is shown in Fig. 45 (*a*), while the construction of the hollow partition is shown in (*b*). In both systems, the Roebling wire lathing, with a solid-steel stiffening rib woven in every 7½ inches, is used for lathing and reinforcing the partition.

76. Solid Construction.—In the **solid partition,** the studding is composed of channel irons, which have the top and bottom ends bent at right angles so that they can be nailed or spiked to the floor and ceiling; to these channel irons the Roebling wire lathing is secured with galvanized wire. The solid partition has a core of cinder concrete 2 inches thick, as shown in the illustration, and both surfaces are plastered in the usual manner. For this partition only two coats of plaster are required—a brown and a finishing coat—and its weight, including the plaster, is approximately 32 pounds per square foot.

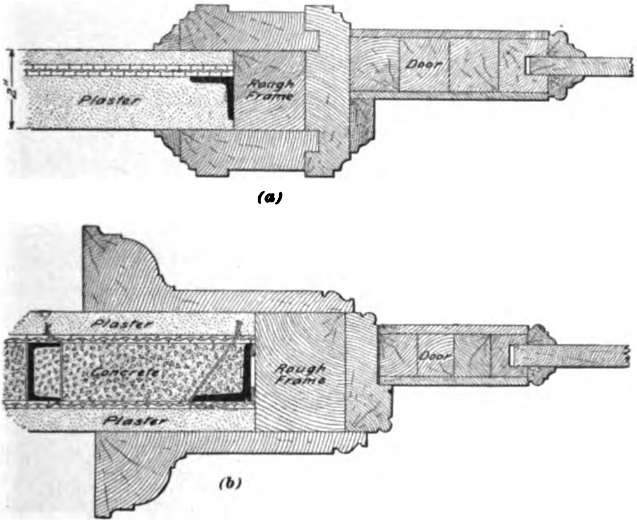


Fig. 46

As cinder concrete will receive nails, no wooden furring is necessary in order to attach the baseboard, chair rail, and picture mold. The size of the door frames and the usual arrangement of the wood trim are shown in Fig. 46 (*a*) and (*b*). It will be noticed that the partition shown in (*a*) is considerably thinner than the one in which a double system of lathing is employed. This single construction is often used, but does not offer so much resistance to fire as the partitions shown in Fig. 45 (*a*) and (*b*), and in Fig. 46 (*b*).

77. Hollow Construction.—The **hollow partition** shown in Fig. 45 (*b*) finishes 4 inches thick when plastered, and has the advantage over the solid partition in being lighter, for it is provided with an air space of about $1\frac{3}{4}$ inches between the plastered surfaces. This air space, besides providing an insulation against sound and heat, is also convenient for the placing of conduits for pipes or electric wiring. In this method of constructing a partition, it is necessary to provide wood furring strips or blocks, which are secured inside of the wire netting by staples, and, wherever possible, the furring should be composed of wood that has been subjected to an efficient process of fireproofing. This type of partition requires three-coat plaster work, and weighs, including the plaster, about 22 pounds per square foot.

Of the two types shown in Fig. 45, the solid partition offers the better fire protection. The hollow partition is not adequate unless fireproof wood is used in its construction, for the falling or breaking off of the plaster coating will expose the wooden furring strips, which in turn will furnish fuel for the fire.

78. Door Frames and Trim.—In first-class work, the door frames and trim for all fireproof partitions should either be made of fireproof wood or be covered with a metallic casing. Art metal work has become so practical and artistic as to provide thoroughly architectural and substantial casings for doors and frames, and also for baseboards and other finish.

EXPANDED-METAL PARTITIONS

79. Expanded-metal partitions are very similar in construction to the Roebling woven-wire partitions, the principal difference being that expanded metal instead of woven

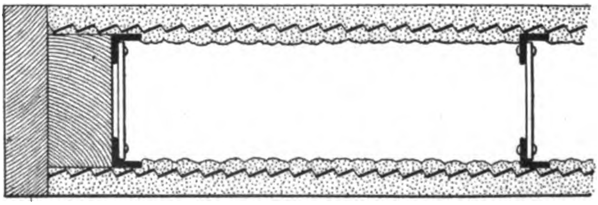


FIG. 47

wire is used for the lathing. Fig. 47 shows a hollow partition made of expanded metal, and angle studs stiffened by

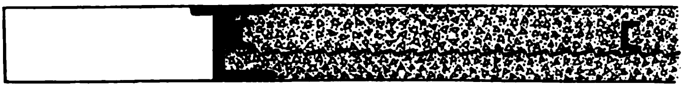


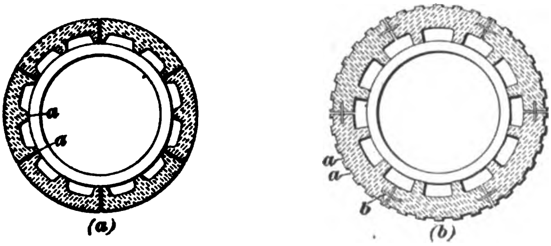
Fig. 48

metal straps. The cement is put on in exactly the same manner as on the Roebling partition. Fig. 48 illustrates a solid partition as arranged for a steel door frame.

FIREPROOFING FOR COLUMNS

TERRA-COTTA SYSTEMS

80. Materials for Fireproofing Columns.—The materials used for fireproofing columns are dense and porous terra-cotta tile; stone and cinder concrete; and expanded-metal and wire lathing covered with cement and fireproofing plasters. All joints must be able to resist moisture and fire. Air spaces provided in the material and between the material and the column offer additional resistance to fire, but they must be stopped at each floor and at several points between floors so as to prevent the possibility of a vertical flue being formed, which would prove destructive in case of fire.



(a) (b)

Fig. 49

81. The simplest forms of **terra-cotta column fireproofing** are illustrated in Fig. 49 (*a*) and (*b*). In (*a*) is shown a covering of terra-cotta segmental blocks protecting a cast-iron column. The inside faces of the blocks have projections *a* that bear against the column and provide air spaces, as shown. These projections also form a support for the blocks and thus prevent them from being displaced.

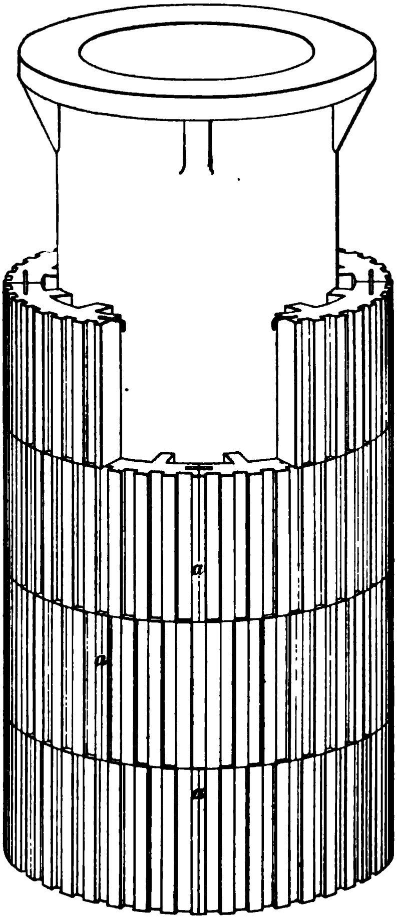


FIG. 50

In (*b*) is shown a similar system in which the outside of the terra-cotta blocks is provided with vertical grooves *a* so as to form a satisfactory base for the plaster. These blocks are set in place with cement mortar and are held together at the joints by the wire binders, or keys, *b*. The blocks are so arranged that all vertical joints *a* will be broken, as shown in Fig. 50. The principal objection to this system is that the blocks are thin and do not adequately protect the columns from heat; also, the fireproofing is liable to be broken or displaced in case of fire, and, in time, the joints are likely to be affected by moisture and heat.

82. To obviate the difficulties just mentioned, the fireproofing tiles shown in Fig. 51 (*a*) and (*b*) may be used. In (*a*) is shown a method of arranging a joint that will not be likely to open, while additional fire protection is furnished by the air spaces *a*.

The protection for the *Phœnix column* is shown in (*b*). The corners *a* of these blocks are molded to suit the requirements of the column, air spaces are provided, and the blocks may be bound at the joints with metal binders *b*. In both types of construction, the fireproofing is held firmly in place and protected from external pressure by occasional header or thicker courses, which extend inwards and come in contact with the surface of the column.

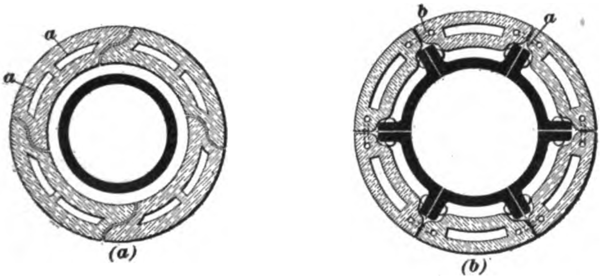


FIG. 51

83. The common systems of fireproofing structural-steel columns are shown in Fig. 52 (*a*) and (*b*). The terra-cotta blocks, shown in (*a*), are usually made about 3 inches thick and are provided with air spaces. They are generally backed with rough brickwork filling or poor concrete; in fact, this construction is the best, for without such a backing the fireproofing is not sufficiently strong to remain in place during a serious conflagration.

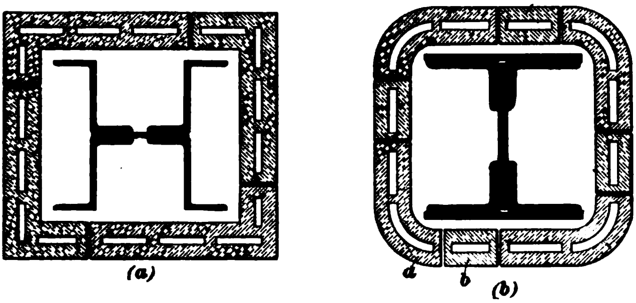


FIG. 52

The construction shown in (*b*) is similar to that shown in (*a*), with the exception that the corner blocks *a* are rounded. By this method, the corner blocks may be made one size, and by changing the length of the block *b*, the fireproofing may be made suitable for any column. Besides setting the terra-cotta tiles in cement mortar, or in some special composition more likely to be fireproof than cement mortar, the blocks are often held in place by binding copper wire around them at intervals of a foot or so.

84. Probably the best system of terra-cotta fireproofing for columns is shown in Fig. 53. Here, the irregular shape of the column section is filled out by special blocks *a*, *a* to a diameter usually equal to about 1½ inches more than the greatest diagonal of the column. Outside of this, a 3- or 4-inch covering of hollow tile is provided with intervening air spaces *b*. These tile are usually arranged so as to break the joints *c* in the filling tile. The outside blocks are kept the proper distance from the filling blocks by headers of thicker tile or by projecting ribs *d* left on the inner surface of the exterior tiles.

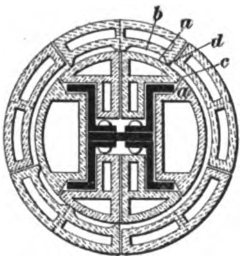


FIG. 53

EXPANDED-METAL AND WOVEN-WIRE SYSTEMS

85. The **expanded-metal system** of column fireproofing consists in wrapping around the column sheets of expanded metal on which the usual plaster is placed. An air space is generally left between the column and the expanded-metal and plaster covering. As shown in Fig. 54, this is accomplished by placing bent pieces *a* of sheet metal vertically on the sides of the column.

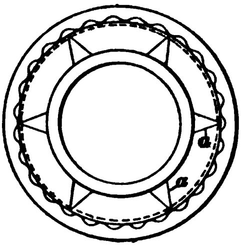


FIG. 54

86. Where the column is small and it is desirable, for architectural effect, to increase the apparent diameter, the system of fireproofing shown in Fig. 55 is used. This column is known as the **Larimer column,** and is built to the required diameter by means of a light bar-iron frame and clamps *a*, *a*. The expanded metal is wrapped around the outside of this framework and plastered, as shown. Where the column is an important member in the structure, at least two coverings of expanded metal and plastering should be provided.

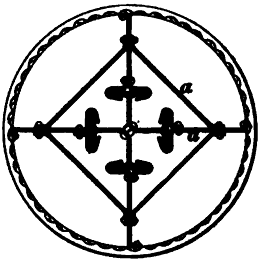


FIG. 55

87. The arrangement of the fireproofing material when two coverings are required is illustrated in Fig. 56. Here is shown the section of a **Grey column** that is first protected by a wrapping of expanded metal and plaster; then, vertical metallic furring strips *a* are fastened in place, and on them is secured a second wrapping of expanded metal, which carries the external plaster. In this manner, not only is an air space provided around the column, but a double covering is secured, so that if the outside is damaged, the column is still protected to a certain extent. This method is considered good practice and provides adequate protection, for the expanded metal and plaster forms a tenacious covering. If the spaces *b*, *b*, Fig. 56, are filled with concrete and a coating of some waterproof material is placed on the outside of the plaster *c*, an almost indestructible type of column fireproofing can be obtained. This method of construction should be employed where the column is of vital importance to the structure.

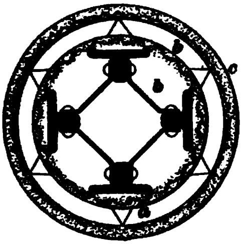


FIG. 56

88. Roebling System.—The **Roebling system,** which is an excellent method for fireproofing columns, consists of woven-wire lathing and cinder concrete constructed as shown in Fig. 57. The woven wire, which contains reinforcing wires every 7½ inches, is wrapped around small channels or $\frac{5}{16}$-inch round rods *a*, *a*. These rods form the furring, which is held 2 or 3 inches from the columns by means of bar-iron supports, or clamps, *b*. The space between the woven wire and the column is filled with cinder concrete of the usual proportions, while on the outside of the woven-wire lathing the finished plaster coating is put in place.

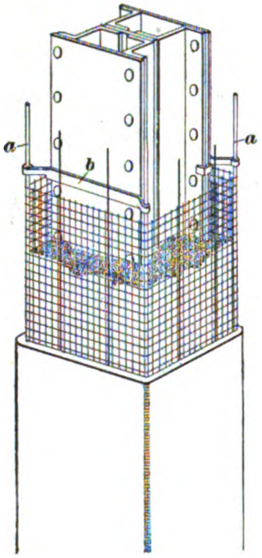
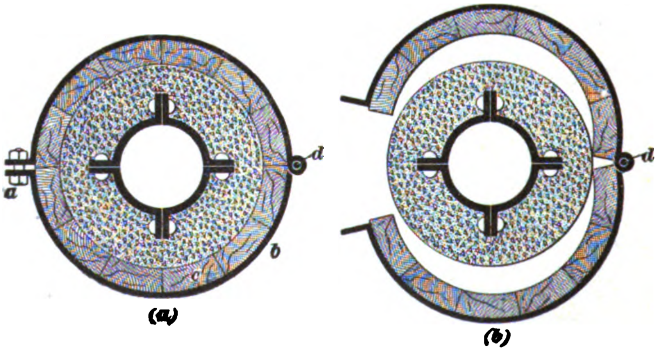


FIG. 57

CONCRETE SYSTEM OF COLUMN FIREPROOFING

89. Concrete is used extensively for fireproofing columns. Owing to its refractory properties and to the fact that it can be readily molded to any shape of column, and also because the materials of which it is composed can be readily obtained in any locality at moderate cost, concrete makes a practical system of fireproofing that is superior to the others.

Fig. 58 (*a*) and (*b*) illustrates the section of a Phœnix column completely protected by a concrete casing. In (*a*) is shown the concrete surrounded by the mold, which consists of 2-inch planks, or staves, *c* held together by heavy



(*a*) (*b*)

FIG. 58

bar-iron straps *b*. These straps are made in halves, the same as the molds, are hinged at *d*, and are bent to form a clamp *a*, being provided with bolts so that the mold can be drawn tightly together. These molds are made in about 4-foot lengths, and after the concrete has been tamped in place and has had time to set, the bolts are removed and the molds taken away, as shown in (*b*). They are then applied to another column or another section of the same column, being supported in the proper position by a false work, or scantling. By the use of a mold for each column, the fireproofing of all the columns can be carried along simultaneously. Since, however, 24 hours should elapse before the mold is removed, the columns should be fireproofed in groups of three or four, so that each group can be laid and tamped consecutively. When the last group is completed, the workmen may return to the first group, in which the concrete has obtained the initial set.

90. Protection of Box Columns.—In Fig. 59 is shown a box column protected with concrete; this method can be used to advantage in warehouses. A section of the column,

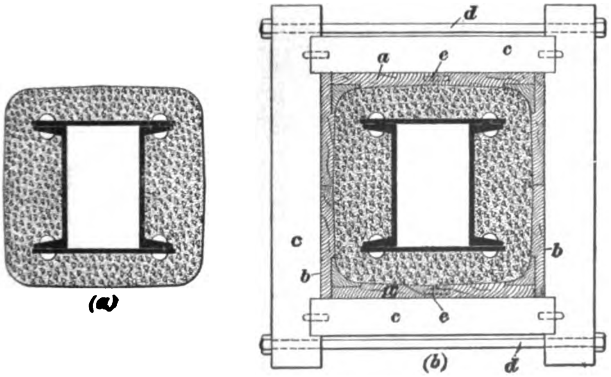


FIG. 59

with its fireproof covering, is shown in (*a*). The mold, or form, for the concrete protection, shown in (*b*), is made in halves that are provided with dowel-pins *e*, so that the two sections will always come together evenly. The side pieces *a* are tapered or provided with a draft so that the form will readily draw away from the concrete when it has set. In order to make the column symmetrical, the other sides *b* of the mold are tapered toward the center. The wooden mold is held together by clamps *c* composed of 3″ × 4″ timbers and provided with bolts *d*. When the concrete has set, the bolts are withdrawn and the mold removed from the column and set up at another place. The molds are made from 4 to 6 feet in length and are provided with a yoke, or clamp, at each end.

91. Advantages of Concrete Protection.—The advantages of the concrete system are obvious, for the concrete cannot readily be damaged or broken; it is an excellent non-conductor, and protects the column not only from heat but also from corrosion. When the location permits and the column is a closed section, corrosion on the inside may be prevented by filling the column with concrete. The concrete is likely, also, to increase the strength of the column, and tends to promote rigidity throughout the structure. In fact, where the concrete is well tamped and is used inside of the column as well as outside, the usual column formula may be neglected, and the safe direct unit stress of the steel may be considered in designing the column, as the concrete effectually prevents any lateral deflection. Such a system of fireproofing will materially strengthen columns loaded eccentrically.

PIPES ADJACENT TO COLUMNS

92. Supply and vent pipes should never be carried inside the fireproof casing and immediately adjacent to the columns, because the condensation on the pipes is likely to cause corrosion, and also because it is impossible to inspect or repair them without practically rebuilding the fireproofing. It has been a common practice—though one that cannot be recommended—to run all piping and electric conduits adjacent to the columns, and in some cases even the plinth plates between the columns of the several stories have been cut to provide a passage. Such practice cannot be too severely condemned. Fig. 60 shows a cast-iron column provided with an eccentric fireproof covering so as to allow a passageway for pipes. This construction is objectionable for the reasons just mentioned.

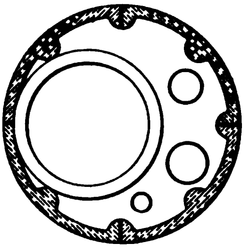


Fig. 60

In Fig. 61, the fireproofing around the columns is provided with a section that can be readily removed. This arrangement obviates the necessity of destroying the fireproof covering in order to gain access to the pipes or wiring that runs adjacent to the column. In removing this covering, however, the plastering adjacent to it has to be destroyed and the work must be replastered. This method does not, however, separate the piping from close proximity to the column as does the construction shown in Fig. 62, which is the method that should be used where it is absolutely necessary to run the pipes and conduits along the columns. The column is fireproofed independently of the pipes, which can be replaced or removed without

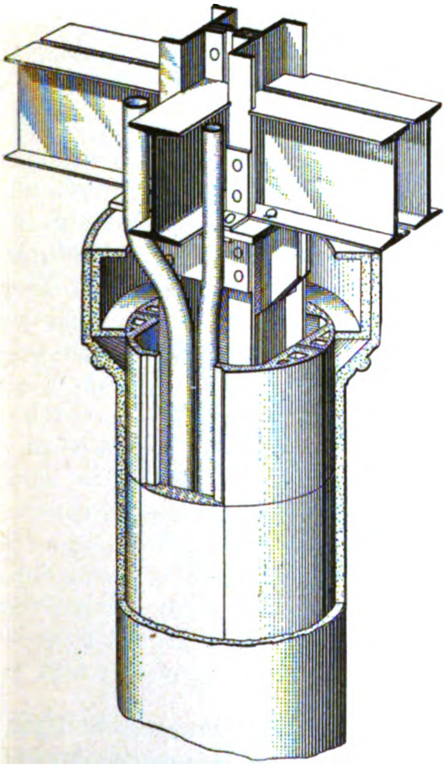


Fig. 61

injury to the column fireproofing; in addition, the possibility of condensation or leakage penetrating to the column is remote.

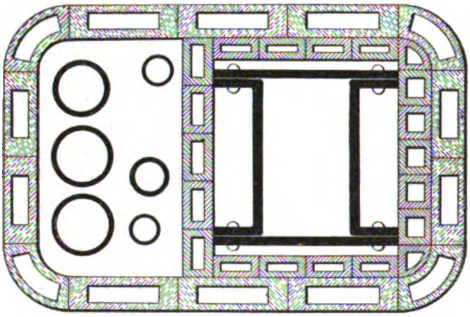


FIG. 62

FIREPROOF LATHING AND PLASTERING

93. Girder Protection.—Cornices to protect and conceal girders are often formed by constructing a frame of light iron strips and covering it with wire lath, to which the plaster is applied. This method of casing a girder is illustrated in Fig. 63, which shows a stiff framework of light iron *a*, which is bent to form the desired outline and is attached to the girder by clamps *b* and *c*. To this frame is fastened the wire cloth *d*, on which the plaster *e* is laid.

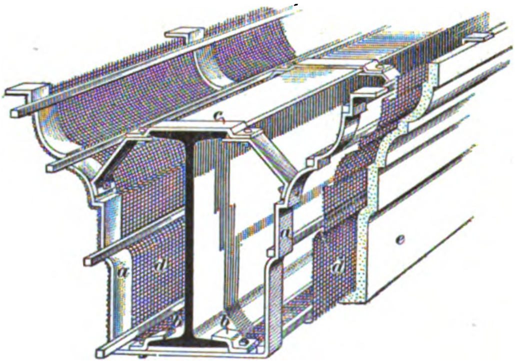


FIG. 63

94. Column Protection.—Fig. 64 shows the method of casing a column, using a framework similar to that just mentioned and securely fastening it to the column. At (*a*) and (*b*) are indicated the methods of forming round and square columns. The wire cloth *a* is wrapped around and fastened to light frames *b*, which are spaced at proper distances and firmly clamped, as at *c*, to the column *d*.

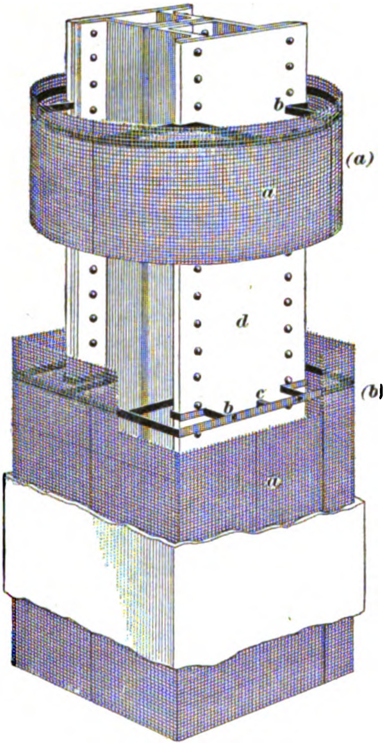


FIG. 64

FIREPROOF WOOD

95. The necessity for a thoroughly fireproof wood as a fire retardant, and also as a means of reducing the amount of combustible material in a building, has been felt since the first efforts were made toward establishing a fireproof system of construction. There are many methods of making wood or timber fireproof; the most inefficient are those that attempt to accomplish the end by paints and superficial applications of fire-resisting chemicals, while the efficient methods are those that impregnate the fibers with some chemical that surrounds the wood cells and produces a coating that effectively protects the timber from combustion.

96. Electrical Process.—A well-known process is the **electrical process.** In this process, all sap and fermenting substances are removed from the timber first by saturation, and then by evaporation. Afterwards the timber is put into cylinders where it is carefully subjected to a solution of sulphates and phosphates of ammonia under a pressure of from 80 to 120 pounds per square inch, the pressure varying with the character of the timber and the closeness of its grain. Before being taken from the cylinder, the timber is carefully inspected and its weight before treatment is compared with its weight after impregnation. In this way, the percentage of fireproofing solution absorbed is found. When the planks are withdrawn they weigh nearly twice as much as when they went into the cylinders, and after they are kiln-dried they usually contain about 6 ounces of the fireproofing substance to the board foot. In the inspection, usually one or two planks are cut through the center to determine whether the solution has permeated the entire mass of the timber.

97. New York Building Department Tests.—The New York Building Department has made a thorough test of fireproof wood and the care with which it was conducted and the evident severity of the test is apparent in the following copy of the official record of the proceedings:

"A small frame structure 12 feet 4 inches by 18 feet 5 inches and 16 feet 4 inches high, divided into two rooms, had a cupola in the center 3 feet 2 inches by 6 feet, extending 10 feet 9 inches above the top of the main structure, which was also divided in the center, making a separate flue for each room. One of the rooms was left with the studding and rafters exposed, while the other had a mantel fireplace and paneled sides and ceiling, exhibiting the finish of the different kinds of wood used in trimming fireproof buildings. The structure was built at the foot of Nineteenth Street and East River, and on the day of the test was placed on a barge, the floor of which was protected by three layers of 1⅛-inch mahogany, and was towed to the foot of Eighty-Sixth Street and East River, where the test was made.

"A small quantity of fuel was kept constantly ignited in the fireplace, and burned for several hours, with the effect of charring a small hole through the lower part of the mantel back.

"Fuel, consisting of shavings, pine cordwood, and barrel staves, well saturated with kerosene, was placed on top of the barge beneath the first tier of beams of the unfinished room, and being lighted and fire rekindled from time to time, burned for 35 minutes.

"Fuel, same as above, was also placed in the unfinished room next the partition, and being lighted and fire rekindled from time to time, burned fiercely for 21 minutes, after which time no flames were seen issuing from the top of the cupola, and the interior gradually cooled, leaving the wood charred. The building remained practically intact at end of test.

"From the results of the test as made, and from reading the reports on file in this department, the general opinion is that wood treated by this process is a fire preventive, and may be used in buildings, in accordance with Section 105 of the Building Code."

98. Qualities of Fireproof Wood.—Fireproof wood is a desirable material for the interior trim of office buildings, and as a fire preventive should be more generally used. It has been demonstrated almost conclusively that the chemically treated wood is as desirable and can be finished as well as the natural wood. When the fireproof wood is well kiln-dried, it is not liable to warp and shrink, and does not cause the corrosion of nails or screws or hardware that may be attached to it. If any additional expense occurs, owing to difficulty in working fireproof wood over timber not chemically treated, it is slight.

STAIR BUILDING

CONSTRUCTION OF STAIRWAYS

CLASSIFICATION AND DEFINITIONS

1. General Considerations.—Stair building grew out of the necessity of securing an easy and safe passage from one level, or floor, to another. Such a passage might therefore be regarded in its inception as an inclined plane that connects two horizontal planes and is provided with a series of equal risers, or steps, formed for the purpose of giving a sufficient footing to facilitate travel.

The construction of wooden stairways is considered the highest branch of joinery; more care and knowledge are required in their planning, more ingenuity in setting them out, and more skilful workmanship in their execution, than in any other work about a building.

In studying the plan and treatment of a stairway, the architect should consider its adaptability for the building in which it is to be placed, its proposed location, the weight likely to come on it, the width to accommodate probable travel, and, especially, the ease of travel. It is not enough, as is sometimes done, to roughly calculate the treads and risers and sketch on the winders, leaving the stair builder to make the best he can of the conditions.

In designing stairways, the first and most important consideration is to arrange them so as to afford the greatest ease of communication to the stories with which they connect. Care should be taken to allow proper headroom for ascending and descending, and the treads and risers should be arranged

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so as to permit easy travel. The proper width of a stairway also has much to do with its appearance. In private houses, the width should never be less than 2 feet 8 inches, and in public buildings never less than 4 feet 6 inches. The staircase in which the stairway is enclosed should be given special attention, and the correct length and width should also be carefully considered. It is not conducive to sound construction to be obliged to cut out trimmer beams; neither is it good practice to have to piece out a few inches when the staircase has been framed too large.

The importance of proper arrangement of stairways is evident, when it is considered that they are seen by every one, their convenience and beauty being readily appreciated and their faults and defects instantly detected.

2. **Materials Used.**—In the construction of stairways, the most commonly used materials are stone, iron, and wood, and their selection depends on the location of the stairway and the use to which it is to be put. If the stairway is to be built on the outside of a building, stone is preferable, owing to its weathering qualities. If, however, the stairway is to be erected on the inside of a building designed to be fireproof, iron is generally employed, because of its better fire-resisting qualities. Either iron and stone is preferable to wood when used in public buildings where the amount of travel requires extra strength. Wood, however, is the material most commonly used, especially in private buildings, where no heavy travel occurs.

3. **Stair-Building Terms.**—In stair building, a *riser* and *tread* together are termed a **step**, the **riser** being the upright portion that supports the **tread**, or horizontal part, on which the foot is placed. The **nosing** is the projection of the tread beyond the face of the riser.

The term **run** is applied to the aggregate width of the treads.

Where the risers are parallel with each other on plan, thus forming straight steps, the steps are called **fliers**; but where the risers radiate on plan, the steps are called **winders.**

The term **flight** designates a succession of steps between one starting point and the one next above it. The spaces wider than steps, which constitute resting places between the flights, or which are the terminations of the stairways, are termed **landings, or platforms.** If the landing is square and occupies half the width of the stairway, it is called a **quarter-space landing**; but when it takes in the full width of the stairway, it is called a **half-space landing.**

The space required for landings is sometimes filled in by winders; this is especially the case in geometrical stairways and those in which the run is limited. Usually, the required rise and run in the given space decide the nature of the landing, whether it is to be quarter or half space, or filled in with winders. Where the run is unlimited, a half-space landing should be adopted; but where the run does not allow this kind of a landing, a quarter space is preferable to winders, as the latter should never be put in a stairway when they can be avoided.

When the lower step of a flight has its outer end in the form of a horizontal spiral, it is termed a **curtail step.** When the outer end of the lower step is rounded to a semicircle, it is a **bull-nose step.** Where steps have an outward curve, they are called **swelled steps**; this form is generally used when the front stringer is curved out at the starting of the stairway.

If, in ascending a stairway, the hand rail is on the right-hand side, the stairway is called a **right-hand stairway.** If the hand rail is on the left-hand side, the stairway is called a **left-hand stairway.**

The foregoing are some of the more common terms used in stair building; others will be explained as occasion arises for their use.

4. General Classification of Stairways.—Stairways are known as *dog-leg*, *open newel*, and *geometrical*. A **dog-leg stairway** has no well hole, and the face stringer of the upper flight is vertically over that of the lower one. A **well hole** is the vertical clear space between flights when the stringers of the return or upper flights are not located in the same vertical plane as the lower ones. The objection to dog-leg stairways is that the hand rail is not continuous, but strikes the soffit of the upper flight.

Where newels are placed at the angles of the well hole, the stairway is termed an **open-newel stairway**; but when the stringer is continued unobstructed by newels in a curve around the winders, the stringer is said to be *wreathed*, and the stairway is designated as **geometrical.**

5. The foregoing classification relates more especially to the general design than to the structural details, many of which are common to each. When classified with relation to the methods of construction, there are two systems: the first consists in the use of rough timbers, or *carriages*, cut to the angle of intersection between the treads and risers. as shown in Fig. 1; the other, which is more generally used, has the treads and risers tongued, or *housed*, from $\frac{1}{4}$ to $\frac{3}{8}$ inch, into the grooved stringers.

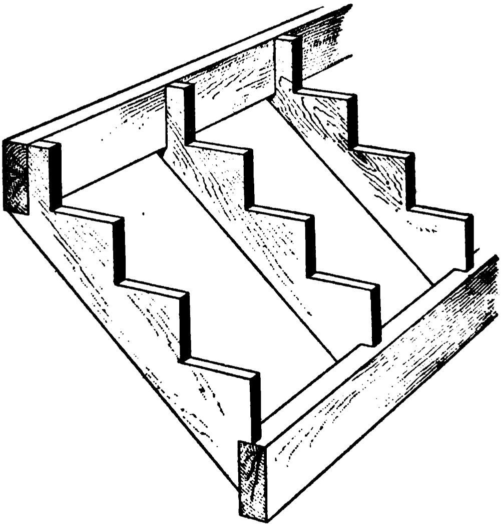


Fig. 1

In the first case, the treads and risers are nailed on the carriages, and, where they intersect with the wall; a board of the same thickness as the baseboard connecting with the stairway is *scribed*, or cut, to the required outline so as to fit closely the angles of treads and risers; this board runs the full length of the stairway, forming what is termed the **wall stringer.** In favor of this method of construction are its simplicity and strength. Against its adoption may be adduced the great difficulty of satisfactorily scribing the wall stringers, and even when this is successfully done, the stairway is likely, in time, through shrinkage and jarring, to show imperfections.

The carriages, also called *horses* and *springing trees*, for the second form of construction of stairways are not cut to the angle of treads and risers, as is the case in the first method, but are simply straight scantlings of sufficient strength to support the stairway and its probable load, rough brackets being nailed on the sides of these scantlings and fitted tightly under each tread and against the riser, as shown at *a*, Fig. 2.

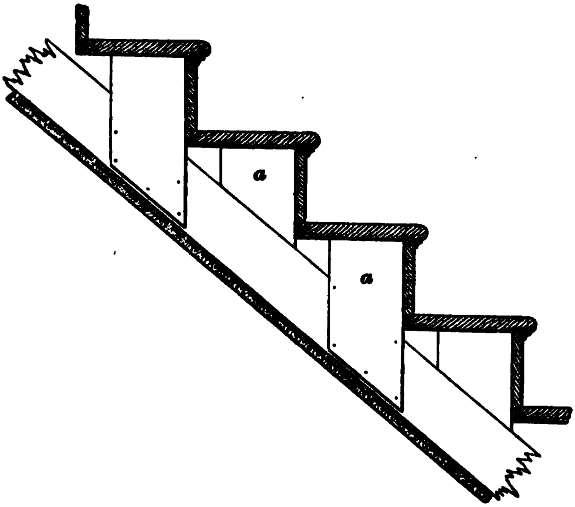


FIG. 2

6. In some cases, where the treads and risers are enclosed in stringers, the wall stringer only is housed to receive the treads and risers, the front, or outer, stringer being cut square to receive the tread and mitered to receive the riser. When thus prepared, the front stringer is termed a **cut-and-mitered,** or **open, stringer,** and the wall stringer is termed a **housed stringer.** Occasionally, both the wall and the front stringer are housed, in which case the front stringer is said to be a **box,** or **close, stringer.** Geometrical stairways are seldom thus constructed, the method being mostly confined to dog-leg and open-newel stairways.

In geometrical stairways, the front stringer is cut and mitered so as to meet the conditions arising from the wreathed portion of the stringer and rail, which are assumed to be parallel with each other in the same vertical plane. The rail in this case is supported by the balusters and starting newel, instead of by newels, and the cut-and-mitered stringer affords a substantial footing for the balusters, which are dovetailed, glued, and nailed to the ends of the treads, the nosing and molding of the treads being returned their full width on the face of the stringer. Stairs thus constructed are said to have *nosed-and-mitered moldings*, and when brackets are placed along the front stringer below the nosing, the stairway is known as a **bracketed stringer.**

DETAILS OF CONSTRUCTION

RISERS AND TREADS

7. Height of Risers.—In setting out a stairway, the first consideration should be to ascertain the exact height between the floors by measuring from the top of one floor to the top of the floor above. For this purpose, a rule, or rod, called a *story rod*, is sometimes used, on which the whole number of risers is to be marked. Care should be exercised in determining the risers, with the view of constructing a stairway that will have steps of convenient height. Experience teaches that a rise between 6 and 7 inches is the limit of easy stepping; therefore, in order to find the number of risers required, the total height of the story rod should be divided by either one of these figures. Having in this manner ascertained the number needed, divide the height of the story rod by the number of risers; the quotient will be the exact height of each riser.

8. Proportioning Treads and Risers.—The next step is to ascertain the width of the treads, not forgetting the rules of proportion between treads and risers, and always remembering that, owing to the landing not being counted as a tread, the number of treads in each flight is one less than the number of risers.

There are several rules for ascertaining the proportion that should exist between a tread and a riser for regular stairways and that determines not only the appearance of the stairway, but also the ease with which it may be traveled.

Three rules will be given, of which the first is the simplest and is generally preferred.

Rule I.—*Let the product of the tread and riser equal the number 66.*

For example, assume that the riser is 6 inches high, then the width of the tread will be 66 ÷ 6 = 11 inches. In the same way, the width of tread may be assumed and the height of the riser found.

Rule II.—*To any given height of riser in inches, add a number that will make the sum equal 12; double the number added, and the result will be the width of the tread in inches.*

For example, assume that the height of a riser is 7 inches; then 7 + 5 = 12, and 5 × 2 = 10, the width of the tread in inches.

Rule III.—*Draw a right triangle, as shown in Fig. 3, with a base of 24 inches and altitude of 11 inches. Mark the width of tread from a on line a b, as a c; at c erect a perpendicular, cutting the hypotenuse at e. Then c e indicates the riser.*

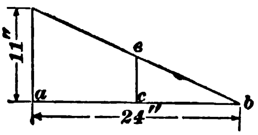


FIG. 3

HEADROOM

9. In trimming joists of staircases, the two cross-beams, which are called *headers*, should be so placed as to allow sufficient headroom to meet all probable requirements of a stairway. The header (which determines the headroom) should be placed so as to secure 7 feet of headroom from the tread vertically beneath it. A careful drawing of the elevation of the stairway will accurately determine this point.

In cases where a number of winders are placed at the bottom of a stairway, and the risers thereby stand one above the other at the center from which they radiate, a considerable rise is produced at the commencement of the run, the amount depending on the number of winders. In such a case, the header is placed at the extreme end of the staircase and thus ceases to be a factor in the headroom. This applies especially to *boxed stairways*, which are enclosed between partitions.

Care should be taken to make the staircase of the correct width, which should be at least 5 inches wider than the stairway; that is, the distance across the cylinder from the center of the rail of the flight to the fascia of the floor landing should be at least 5 inches, to permit the rail of the flight to pass clear of the nosing on the landing.

STRINGERS

10. Laying Out.—A straight stringer is laid out by means of a **pitch board**, which is shown in Fig. 4 (*a*). This board should be made of thin wood, the grain running parallel with the hypotenuse so that the effects of shrinkage will be the least possible. The base is cut to equal the tread, and the perpendicular to equal the riser.

In (*b*) is shown the stringer as marked out for the steps. The dotted line *a b* is drawn at a sufficient distance from the edge to permit the lower edges of the riser and tread to intersect on the line of the under side of the stringer, as shown at *d*; and on the line *a b*, distances equal to the slope length of the pitch board are stepped off with dividers. The pitch board may then be applied as indicated, and its outline marked on the stringer edges.

Templets, as shown in (*c*), should be made for the treads, risers, and wedges, care being taken that the pitches are alike, so that wedges of the same shape can be used. The lines *a d c b* show the section of the tread; and *a e f* shows the shape of the wedge. When applied to the stringer, the tread-and-riser templets should have their outer edges coincide with the lines made from the pitch board, giving the outline shown at *S*, Fig. 4 (*b*).

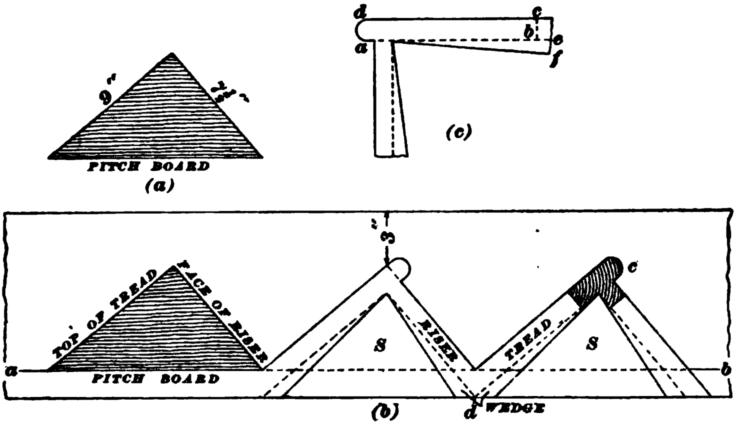


FIG. 4

11. To form the housing, holes are bored in the stringers adjacent to the nosing of the tread, as at *c*, Fig. 4 (*b*), and that portion is removed by means of a chisel. The lines of the templets may then be cut to the depth of the groove with a saw, and the material removed with a router plane.

Such a stringer is shown in Fig. 5, with the exception that the under edge is kept somewhat lower than the point *d*, Fig. 4 (*b*), and is preferable to the latter method in that the wedges are well supported at their outer ends. If the staircase will allow the insertion of the assembled parts, the treads and risers are attached to the stringers, wedged and glued into the housing, and the whole taken bodily to its

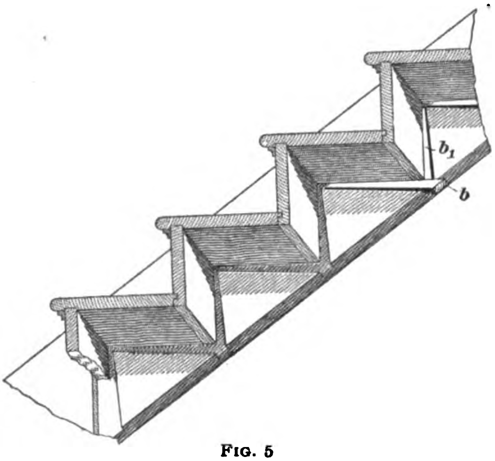


FIG. 5

place in the building. The wedges are shown in place at *b* and b_1, Fig. 5.

12. The wall stringer, as shown in Fig. 6, and also the front stringer, if a close one, are each grooved as already explained, the depth depending on the thickness of the

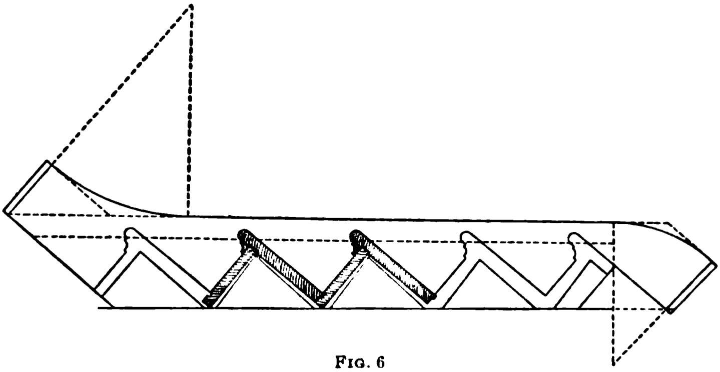


FIG. 6

stringer. Two or more carriage timbers are used in the width of the stairway, the number, depth, and thickness depending on the width of the stairway and the load to be carried.

The front stringer, as shown in Fig. 7, is well nailed to the front carriage timber *a*, while the other timbers are rough-bracketed under each step alternately on the sides, and nailed as shown at *a*, Fig. 2. A furring strip to receive the lath is nailed to the wall in line with the lower edge of the carriage timbers. The prepared mortised wall stringer is nailed to the wall to square properly with the previously set carriage timber and front stringer.

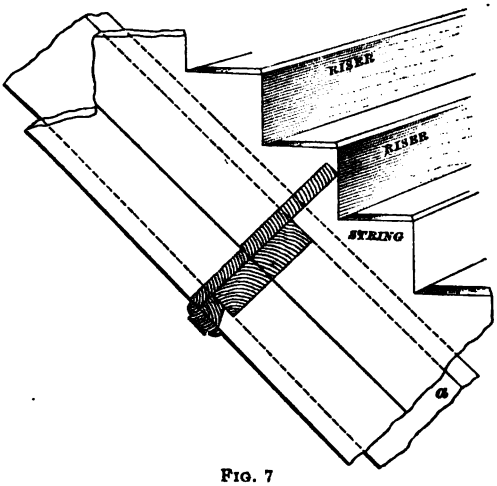


FIG. 7

13. Scribing Wall Stringers.—When the treads and risers are supported by rough-cut carriages, it becomes necessary to cut a wall stringer that will fit around the steps and make a finish with the wall. In Fig. 8 is shown a method of *scribing* a wall stringer. The stringer is represented as being laid with one edge on the line of the nosings, and the instrument to be used is shown in position. The hardwood or iron bar *b h* has a hook on the lower end, which projects sufficiently to enable the bar to clear the nosing when the point *b* is touching the face of the riser. The bar *b h* is placed against the guide *m*, being loosely bound to it by the metal straps *e* and *k*. The strip *n* is fastened to *m* by a bolt *a*, which can be tightened so as to preserve the bevel. A small nick is made in the sliding bar *b h* at *c*, so that *b c* is the height of a riser. When the point *b* is on the end of the nosing, the nick *c* gives the position of the corresponding point on the wall stringer, which may be marked with a steel point, or pencil. Other points may be found in a similar manner, and the outline to which the wall stringer is to be cut can then be drawn.

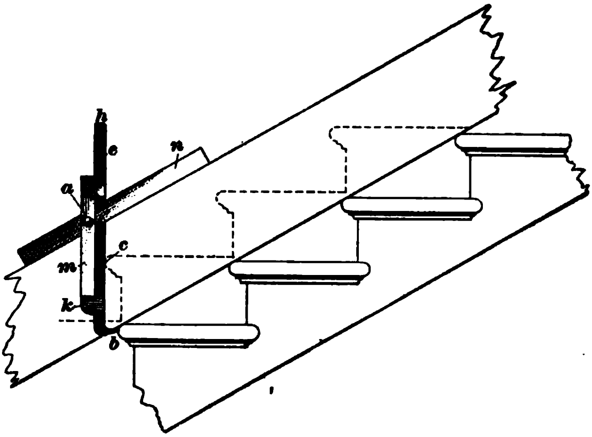


FIG. 8

CONSTRUCTION OF STEPS

14. In constructing steps, a portion of the upper edge of the riser may be tongued into a groove in the under side of the tread, as shown at *a*, in Fig. 9 (*a*), instead of letting the whole thickness of the riser into the tread, as shown at *b* in (*b*). The lower edge of the riser may also be tongued into a groove in the upper surface of the tread beneath it, as shown at *b* in (*a*), in which case the tread will have to be nailed up into the riser as at *c*; this method, however, does not give such good results as that shown at *a* in (*b*).

The finished treads and risers are glued together, being clamped with handscrews until the glue has set. From two to four well-fitted blocks are then glued and nailed to the internal angle of the tread and riser, as shown at *b* in (*b*). In Fig. 9 (*b*) are also shown the dovetails for inserting the balusters.

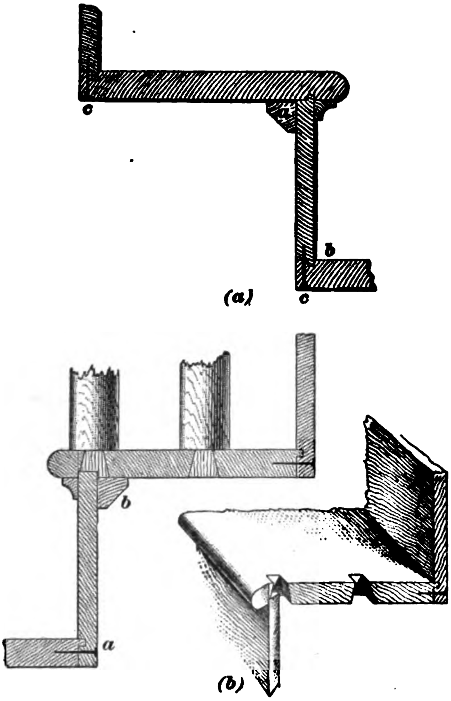


Fig. 9

15. Bull-Nose Steps.—A form of step that is much used is illustrated in Fig. 10. A solid or built-up block of wood is sawed into the shape shown at *e*, and the riser is sawed out as indicated, leaving a veneer to cover the face of the block. The end *b* is firmly fastened to the solid block with screws. At *a*, a square hole is left the full depth of the riser, into which wedges are driven from each end, as suggested at *d*. The back of the veneer is covered with glue, and as the wedges are driven home it is clamped firmly against the face of the block. The newel is generally set on top of this step, as indicated by the dotted lines. The second riser may be placed in line with the middle of the newel, as indicated at *c*, or in any other position desired.

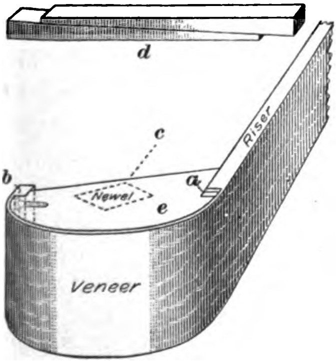


Fig. 10

16. Curved Risers.—Where risers are curved, they should be made of solid wood, or of curved strips of seasoned wood glued solidly together. Frequently, however, seasoned wood in pieces large enough to make a solid curved riser cannot be secured. In such cases it becomes necessary to bend pieces of 1-inch board by kerfing. The method of finding the distance between kerfs for a curve of given radius is as follows: Cut one kerf, as at *a*, Fig. 11; then, marking the distance *ad* equal to the radius *ao* of the curve to which the piece is to be bent, bend the board to position *ab* until the saw kerf is closed, as shown. Measure the distance between *d* and *b*. This length *db* is therefore the distance between kerfs, which, if continued, will shape the board to the curve *ae*. All the kerfs must be made with the same saw and to the same depth.

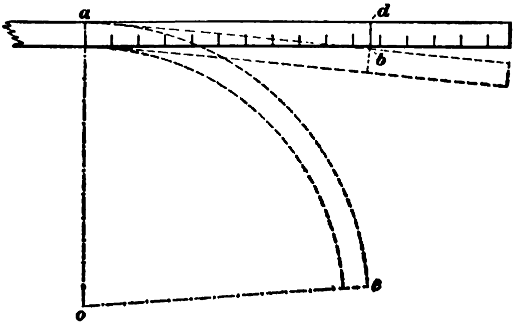


Fig. 11

17. Platforms.—Where the stairways of a building are of considerable length and are straight in plan, it is best to break the flight by a platform, which may be projected from the side wall, as shown in Fig. 12. In a brick wall, the

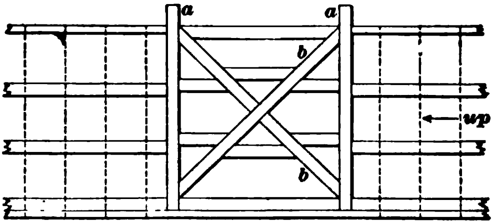


Fig. 12

lookouts *a*, *a* should be set in at least 8 inches, with slip keys tightly wedged between the bricks and the top of the timbers. In frame walls, the lookouts are nailed to the studs. The braces *b*, *b* should be well fitted and spiked to the lookouts. These braces serve to keep the platform square, and should be made of thoroughly seasoned wood. A flight terminating in a platform should not contain more than twelve steps. A perspective sketch of the platform is shown in Fig. 13.

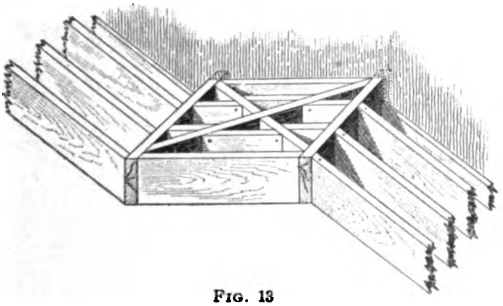


FIG. 13

CYLINDERS

18. In a geometrical stairway, the hand rail, when not obstructed by newels, sometimes travels over six or more flights from the first step to the last; it then becomes necessary to wreath the stringer and rail around the well hole. The well hole thus treated is said to contain a **cylinder**, which is the curved space around which the hand rail and stringer are wreathed. In a circular stairway, the cylinder assumed has a complete circle for its plan, and the stringer and rail are made to wind around it, following a curve termed a *helix*—a curve of the same nature as the winding thread of an ordinary screw. The finished treatment of the stringer and balustrade is continued around the cylinder, and where the stairway terminates in a landing, the same treatment is continued along the trimmer beam. The finishing piece on the face of a landing beam corresponding to the stringer of the flight is called the *fascia*. Thus, it will be seen that the stringer of the flights, the cylinder of the well hole, and the fascia of the trimmer beam are but parts of one continued stringer known by different terms.

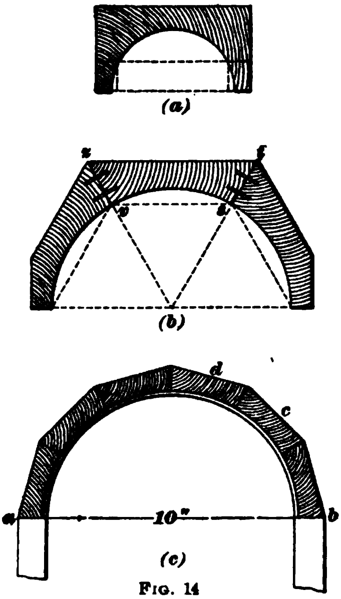


FIG. 14

19. Cylinders are built up as shown in Fig. 14. The construction shown at (*a*) is used for small cylinders, while for larger ones, the methods shown at (*b*) and (*c*) are used. The joints, as *s t* and *v z*, are glued and strengthened by screws or wooden dowel-pins. For extra-fine work the face of the cylinder is veneered, so that the joints of the staves in the semicircle from *a* to *b*, in (*c*), are covered. The veneer is bent over a skeleton cylinder whose diameter is equal to that of the well cylinder, and then backed with properly fitted staves, as *c* and *d*, well glued, and screwed or doweled at the joints, if necessary.

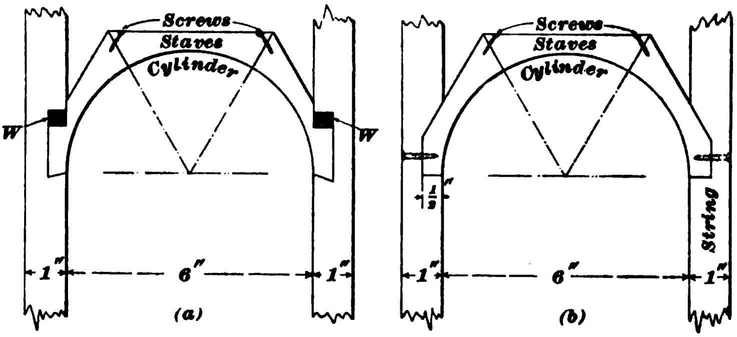


FIG. 15

The end staves of small cylinders are fastened to the stringers in various ways. Two common methods are shown in Fig. 15. In the first method (*a*), a dovetailed groove is cut in the stringer into which the end stave fits. Wedges *W*, glued in, hold the stave in place. In the second method (*b*), the end staves are merely set into the stringers and screwed fast from the outside.

MISCELLANEOUS DETAILS

20. Moldings.—All base and stringer moldings should be worked out of solid wood. Work that is to be bent is generally stronger when laminated, as shown in Fig. 16; but for moldings this method cannot always be used, since the joints will show no matter how well the work is done. This is particularly true of hardwoods. If the work is to be painted, however, this method is not objectionable.

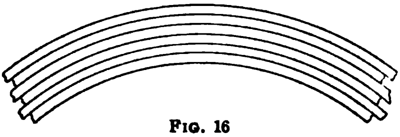


FIG. 16

21. Erection.—If the stairway is put up against the brown-mortared wall, the finished parts must be well covered with building paper. Rough boards should also be placed on the treads and allowed to remain there until the interior woodwork and plastering are completed. The covering, however, should be fixed in such a manner that enough of it can be easily removed to permit the erection of the hand rail and balusters.

When the steps are set in place, they should be carefully inspected to ascertain whether any of them are cut short and pieced, whether any of the wedges are improperly glued, or whether the nailing of treads and risers is omitted. The stairway should make no creaking noise when a person ascends or descends; even a slight creaking is sure to grow louder in time, and thus be a lasting reminder of defective work. Creaking is generally due to defective gluing, nailing, wedging, or to the use of unseasoned stuff in the rough carriages and brackets, or in the finished material.

BALUSTRADES

22. Newels.—**Newel posts,** or **newels,** are used to support the hand rail, and are either made of solid materials and turned, or are built up box-like, in which case they are called **box newels.** They vary in design, form, and size, some—especially the one placed at the bottom of the stairway, called the **starting newel**—often being elaborated with panels and carving.

The newel is also variously fixed in its relation to the steps adjoining; in ordinary cases, it is placed on the floor, and when so placed its center should be in line with the center of the first riser. Where space is limited at the bottom of a stairway, the newel may be placed on top of the first step, or even on top of the second or third step; but in each case, it should be so placed as to have the center of the riser in line with the newel center, and the steps outside rounded and returned into the stringer. The end of the latter is inserted into a prepared mortise in the center of the newel.

The **angle newels** on the landings are generally smaller in size and are treated simpler than the starting newels. The same rule applies to their relation to the risers; namely, that the center of the riser should be in line with the center of the newel. Working from centers in stair-building construction is almost a maxim. The center of the rail is to be in the center of the newel; so, also, is the center of the stringer. The center of the baluster is to be in the center of both the stringer and the rail, and, as stated before, the center of the riser adjoining the newel is to be placed at the center of the latter.

23. Balusters.—**Balusters** are small columns, generally turned, that are set vertically on the ends of treads or on the stringer, forming an ornamental guard and supporting the hand rail. When the front stringer is closed, or housed, the balusters are fixed to the stringer instead of to the treads, a grooved molding, called a *cap*, being prepared to receive them. The lower ends of the balusters in this case are cut to the pitch of the stairway, and the top is either cut to the same pitch as the rail or is mortised into it. This applies to balusters having square ends. Frequently, they are made square or round at the bottom and turned to a spindle shape at the top, being then termed **pin balusters.** Balusters with square bases are preferable to those with round bases, as the bearing surface and resistance to movement of a square base is almost double that of a round base. Holes are bored about an inch deep into the under side of the rail to receive the balusters, and the lower ends of the balusters are either cut to the pitch of the stairway or are dovetailed to the ends of the treads, depending on whether the stringer is housed, or cut and mitered.

In ordinary stairways, two balusters are placed on each tread, but in the better class of stairways, the number is increased, thereby adding to the beauty and strength of the balustrade and to the general appearance of the stairway. The two balusters on a tread are placed half the width of a tread apart between centers, the short one standing close to the nosing and the long one being placed midway between the adjacent nosing balusters, so that it is exactly one-half the rise of the steps longer than the short baluster on the same tread. The usual height of pin balusters is either 2 feet 4 inches or 2 feet 8 inches, of which 1 inch is allowed at each end for insertion into the rail and the tread

In some stairways, the space between the balusters is filled in with brackets of various designs or is paneled. In either case, the number of balusters is reduced to one for each tread, ordinarily placed over the face of each riser, thus leaving the full width of the tread (less the thickness of one baluster) for the decorative brackets or panels.

24. Hand Rails.—The development of hand rails, which involves complex geometrical problems, is not within the province of the architect or builder, though a few remarks regarding their construction are pertinent. Except where the rail is placed over winders, whether at the bottom of the stairway or around the cylinder in the well hole, it should be set parallel with the line of nosings. The inclination of the pitch will be greater over the winders than over the straight rail, and as this determines the height of the rail, it follows that any addition to the pitch over the winders will require more height for the wreath. This additional height, however, should never be such as to cause an unsightly crippled appearance where the curve of the wreath intersects with the straight rail. In stair construction, each baluster should be set vertically and be glued solidly and nailed to the hand rail, so that when tested there shall be no noise, which would indicate the presence of loose balusters through imperfect fitting, poor gluing, or carelessness in nailing.

Where the straight rail enters the newel without a ramp, the newel may be made from 4 to 6 inches shorter than would otherwise be possible, the reduced height often being a matter that should be taken into account. Where such is not the case, the hand rail may be bent upwards (in which case it is said to be *ramped*), so as to enter the newel in a plane perpendicular to it, and the angle of intersection between the raised level portion and the inclined plane of the straight rail is gracefully eased. This last method is the one most commonly adopted, owing to its better appearance.

25. Ramps and Easements.—In an open-newel stairway, the rails usually meet the newels one above the other. To bring the rails to the same level, they must be ramped, and sometimes they are ramped and *kneed*—the latter being a concave easement with its upper end forming an angular knee. When the knee is convex, the combined curve is called a *swan neck* or sometimes a *goose neck*. The lower ends of rails abutting against the newels may be either straight or curved. When curved, the rail is said to be *eased*, and the curved portion of the rail is called the **easement**. This arrangement, however, requires the newel to be somewhat longer.

26. Stiffening Hand Rails.—Continued hand rails are sometimes provided with an iron brace that extends across the cylinder from the fascia to the bottom of the rail. Instead of this brace, an iron baluster is often placed at each end of the wreath. Fig. 17 (*a*) is a perspective sketch of the base of such a baluster, which is formed into a flanged connection and attached to the riser and to the stringer by screws. At (*b*) is shown a side elevation of the base and its relative position with reference to the face stringer.

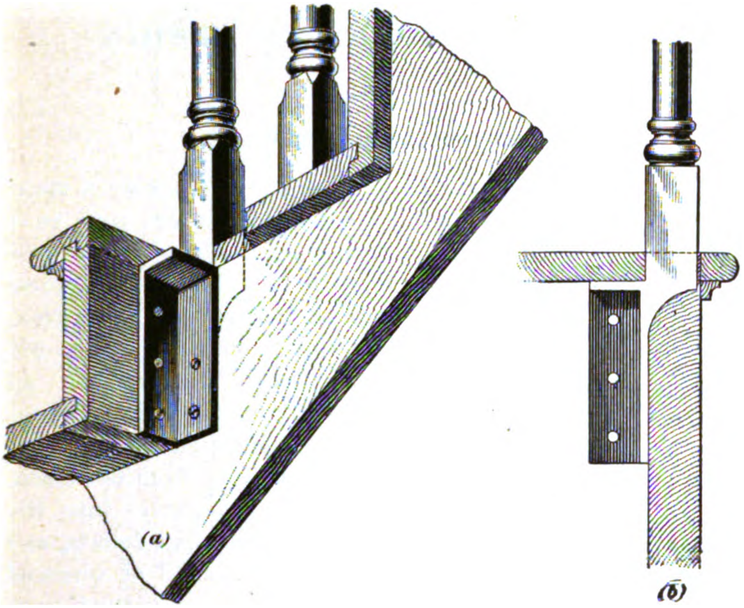


Fig. 17

GENERAL STAIRWAY DESIGN

ORDINARY FORMS

27. Step Ladders.—One of the simplest forms of stairways in use is a fixed or movable **step ladder, such** as is sometimes built from an attic floor to the roof, and shown in Fig. 18, where (*a*) is a plan, and (*b*) an elevation. The top step should always have an increased width, and the sides of the ladder should be at least 6 inches wide by 1⅛ inches thick. The steps are *gained* into the sides not less than ⅜ inch, and are securely nailed or screwed thereto. As shown in the figure, this ladder rises 8 feet, or 96 inches, which, divided by 10, the number of steps, gives 9⅗ inches for each riser. The horizontal distance from the face of the landing beam to the bottom of the ladder equals 3 feet 7 inches. This distance, less 3 inches for additional width of top step, leaves 3 feet 4 inches, or 40 inches, which, divided by 10, the number of treads, gives 4 inches as the width of each tread from its nosing to a vertical line dropped from the nosing above.

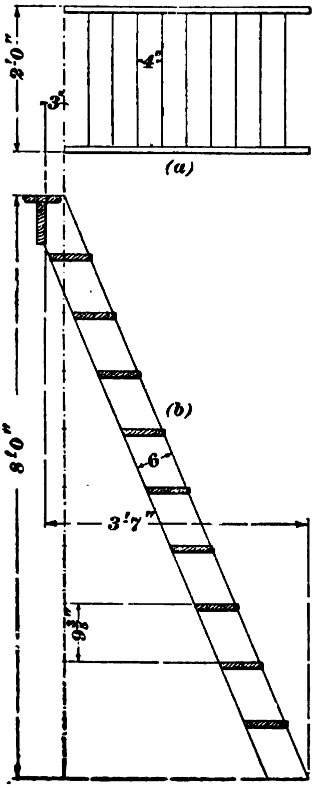


Fig. 18

28. Plank Stairway.—In Fig. 19 (*a*) and (*b*) are shown the plan and elevation of a strong **plank stairway,** such as may be required for a shop or factory; *a* and *b* are newels, 6 inches square, to which 3″ × 1½″ hand rails *c* and *d* are fastened and braced with one or more uprights *e*. In (*c*) is

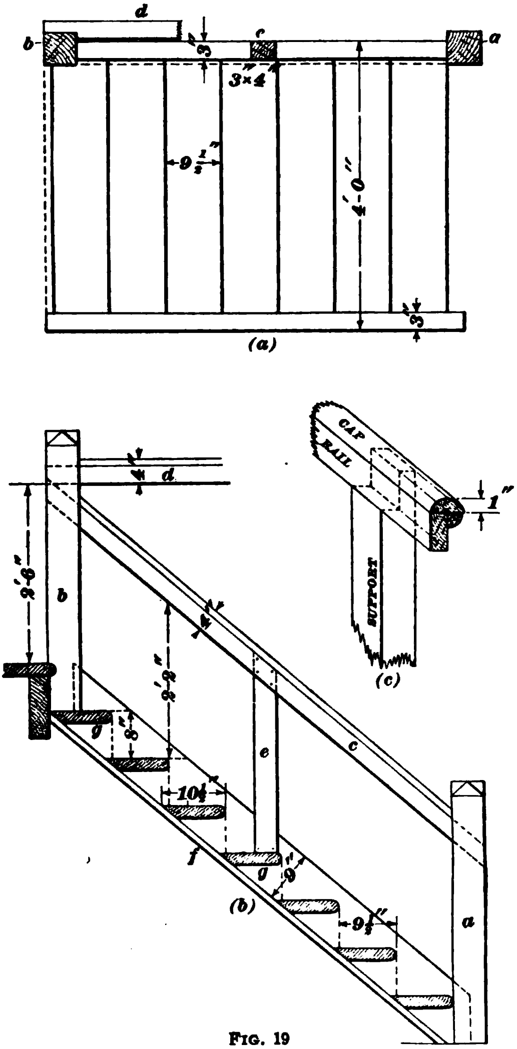


FIG. 19

shown a section of the hand rail. As shown in (*b*), hardwood treads *g*, 2 inches thick, are mortised 1 inch into 3-inch timber stringers, tightly fitted into the mortises, and well spiked, but not wedged. The soffit may be ceiled with matched lining, as at *f*.

GEOMETRICAL STAIRWAYS

29. Straight Stairways.—In Fig. 20 are shown the plan (*a*) and elevation (*b*) of a **straight stairway** with a 6-inch cylinder. The first requirement in planning this stairway is to fix the number and height of risers. The story rod *A*

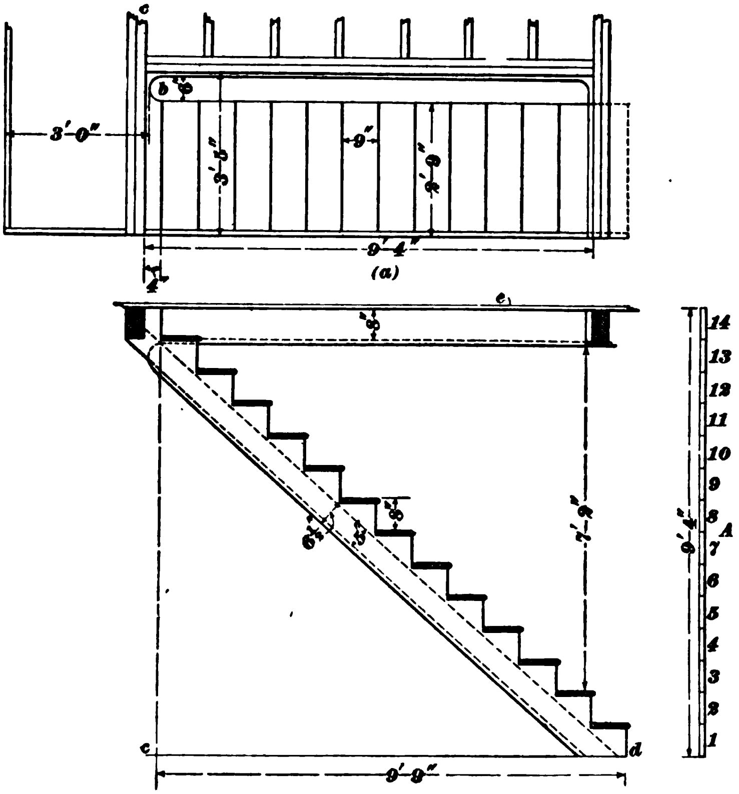


FIG. 20

indicates the height of the story to be 9 feet 4 inches, or 112 inches, which, divided by 14, the number of risers, gives 8 inches as the height of each riser. The total run *cd* is 10 feet 1 inch, less 4 inches for the depth of the cylinder, which leaves 9 feet 9 inches to be divided into thirteen treads, giving 9 inches as the width of each tread. As the floor at the landing makes one of the steps, there is one tread less than there are risers. The width of the stairway, shown in (*a*) as 2 feet 9 inches, is measured from the face of the plaster to the face of the front stringer, while the width of the well includes the width of the stairs, the diameter of the cylinder (in this case, 6 inches), plus 1 inch for the thickness of the fascia, and 1 inch for lath and plaster—altogether 3 feet 5 inches; and, if the outside wall is constructed of brick, 1 inch more for thickness of furring will be required. At the landing of a straight flight, there must be at least as much room between the cylinder and the partition as the width of the stairway, preferably as much more as possible. In this case, 3 feet is the width used in the platform, the 3 inches extra being allowed for convenience in moving furniture, etc.

The headroom of the stairway shown in Fig. 20 is 7 feet 2 inches from the top of the second step to the ceiling, and the point where this headroom can be secured governs the length of the well hole, which as figured on the plan, is 9 feet 4 inches. It is not necessary to make a drawing of the elevation in order to find the length of the well hole for the required headroom, as this can be calculated from the plan by counting twelve risers down. If each riser is 8 inches, the twelve risers make 96 inches. From 96 inches subtract 10 inches, the depth of the floor, giving 7 feet 2 inches as the headroom. The twelve treads of 9 inches each make 9 feet, to which must be added 3 inches for the depth of the cylinder and 1 inch for its thickness, making the total length of well hole 9 feet 4 inches.

The hand rail for such a stairway as this would be from 3 to 3½ inches wide, and the balusters from 1½ to 2 inches, square or turned.

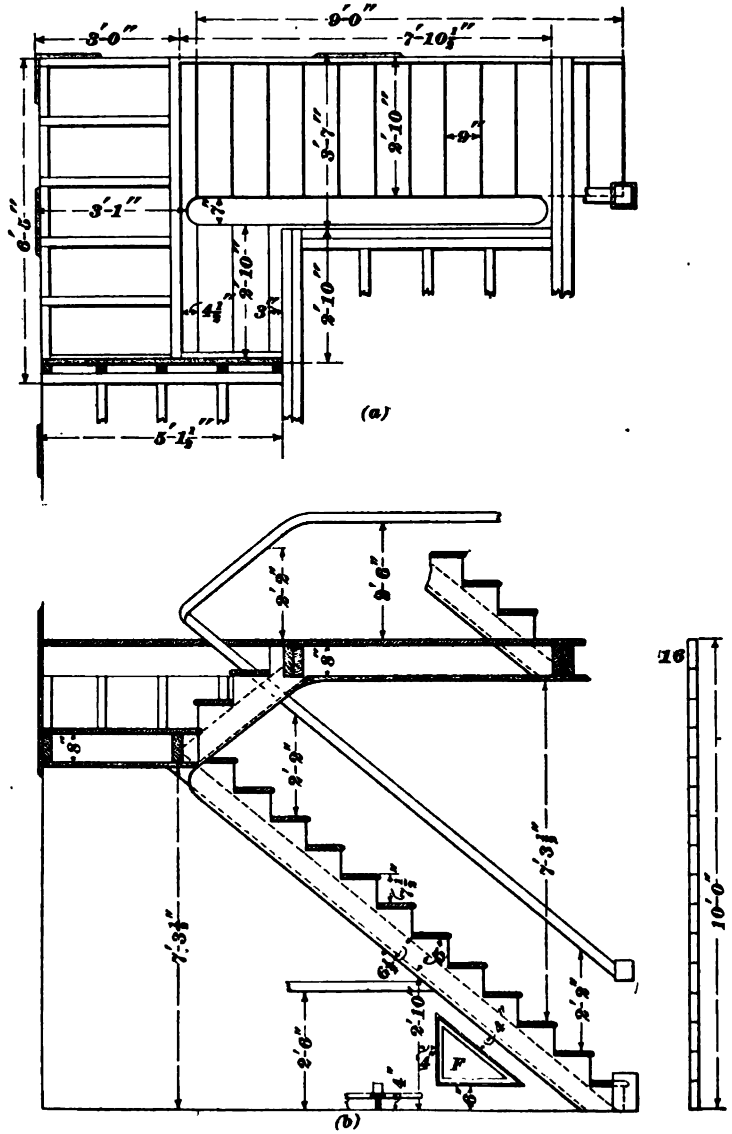

3'-0"
9'-0"
7'-10½"
3'-7"
2'-10"
9"
6'-5"
3'-1"
7"
2'-10"
4½"
3"
2'-10"
5'-1½"
(a)
2'-2"
2'-6"
8"
8"
2'-2"
7'-3½"
7'-3½"
7½"
6¼"
2'-10"
2'-2"
2'-6"
4"
F
6"
16
10'-0"
(b)

Fig. 21

30. Platform Stairways.—In Fig. 21 is shown the plan (*a*) and the elevation (*b*) of a **half-turn platform stairway,** with a continued hand rail around a 7-inch cylinder. A stairway of this kind is easy to ascend, as the flight is broken by a roomy platform. This arrangement also provides space for a window to light the stairway and hall from above the platform, while below it affords room for a doorway to the outside. With the latter purpose in view, the soffit of the platform must not be less than 7 feet in height. The plan also indicates the timber framing of the well and the platform.

A jib panel *F* is shown at the start of the stairway in the elevation (*b*), the object of which is to close and neatly finish the angular space formed by the intersection of the stringer and the floor. The height of the jib panel is such as to receive the hand rail of the basement stairway. Where it is desired, the latter stairway may be enclosed by a paneled or lath-and-plaster partition extending up to the stringer of the upper flight.

The hand rail on the flight is 2 feet 2 inches in height from the center of the short baluster at the top of the step to the bottom of the rail. Along the hallway, the bottom of the rail is 2 feet 6 inches from the floor. These heights are based on the commercial custom of turning ordinary pin balusters in lengths of 2 feet 4 inches and 2 feet 8 inches, 1 inch being allowed for entering the hand rail and 1 inch for the dovetail entering the tread, thus leaving the exposed part the length mentioned.

The half-turn platform stairway can be altered in various ways without changing the number of risers. For instance, a step can be taken from the upper flight and added to the lower flight, increasing the run 9 inches and raising the platform one riser, making it 7 feet 11 inches. Then the well hole for the same headroom must be 9 inches longer, and the beam at the landing of the short flight must be brought forward the same distance. On the other hand, a step may be added to the short flight, making four risers in the short and leaving twelve risers in the long flight. The well hole can now be shortened 9 inches and still have the same headroom as before; but it will be necessary to move the landing beam of the short flight back 9 inches to accommodate the additional step. The platform, however, is one riser lower, making it 6 feet 8 inches; but, if the total depth of the platform can be made 6 inches, thus reducing its depth 4 inches, the height of the soffit of the platform will be 7 feet.

31. Winding Treads.—In Fig. 22 is shown an **enclosed stairway,** illustrating the method of laying out the wall stringer, easement curves, etc. The widths of the winding treads at the wall are projected down from the plan by lines *k l*, *m n*, etc. Then, the wall stringer *a b*, at right angles to the main wall stringer *a e*, is revolved, as shown, parallel with the main wall stringer, and laid out in a similar manner; $a' b' c' d'$ shows the stringer *a b* in elevation. The stringer *e f* is treated in a similar manner. The story rod is shown at the left, and the steps are projected from it and from the plan, as shown at step *4*. Where the treads are wide, as in steps *1*, *2*, and *3*, the line of the nosings makes an angle with the horizontal different from that made by the line of the nosings in the body of the stairway. This is because the uprights, or risers, remain the same, while the horizontals, or treads, vary in width.

32. Easement Curves.—At the angles, easement curves are necessary, or, at least, advisable. At *h*, Fig. 22, is shown a method of drawing an easement curve. From the vertex *h* lay off equal distances in both directions, as *1*, *2*, *3*, *4*, etc. Draw lines from *5* to *6*, *4* to *7*, etc. Through the points of intersection of these lines, draw a curved line by means of a spline. If the angle is sharp, as at *g*, perpendiculars may be drawn at equal distances from *g* until they intersect, as at *o*; the curve can then be drawn with compasses.

33. Items of Detail.—In winding treads, both wall and front stringers are to be mortised, or housed. For the steps, the treads and risers are to be glued together, wedged, and back-nailed, as before explained, in order to secure good,

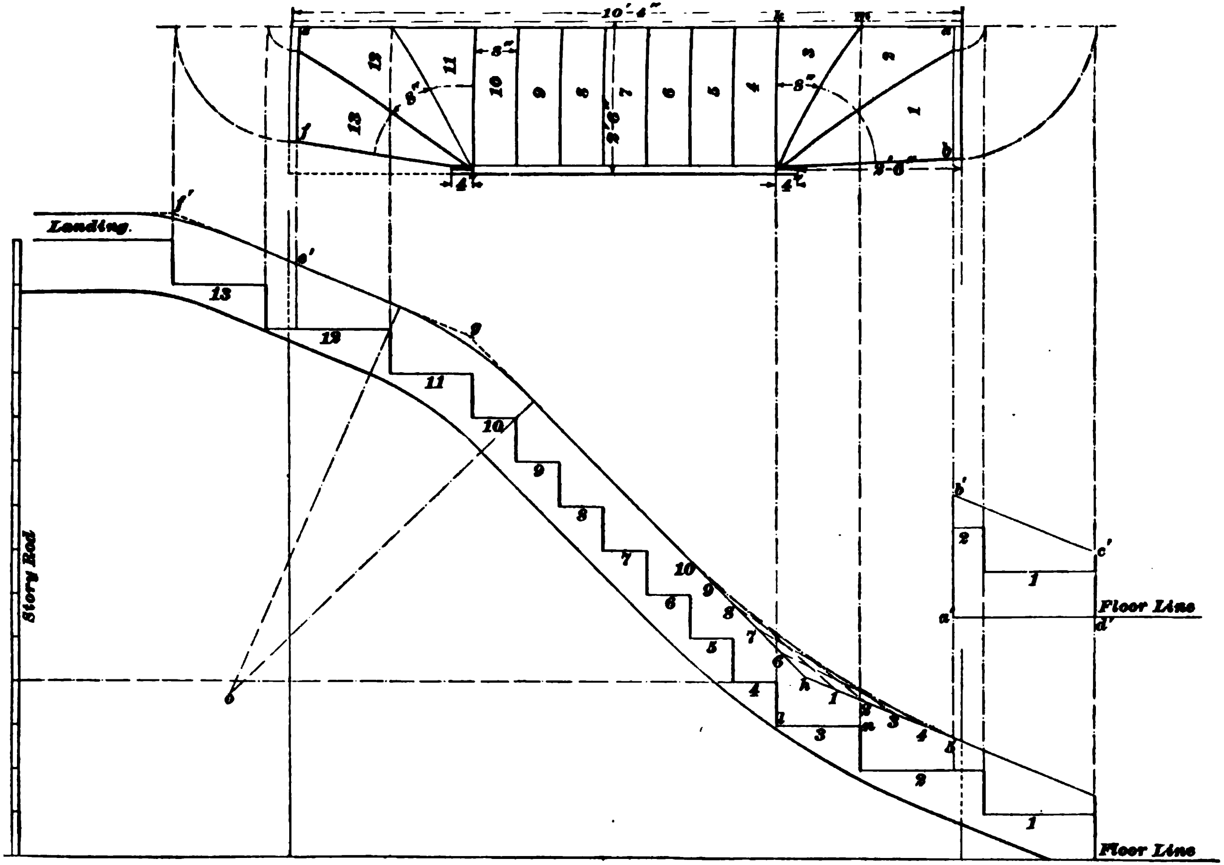

10' 4"
8"
3' 6"
2' 6"
4"
Landing.
Story Rod
Floor Line
Floor Line
a
b
e
f
k
m
h
a'
b'
c'
d'
e'
f'
g
o
1
2
3
4
5
6
7
8
9
10
11
12
13

FIG. 22

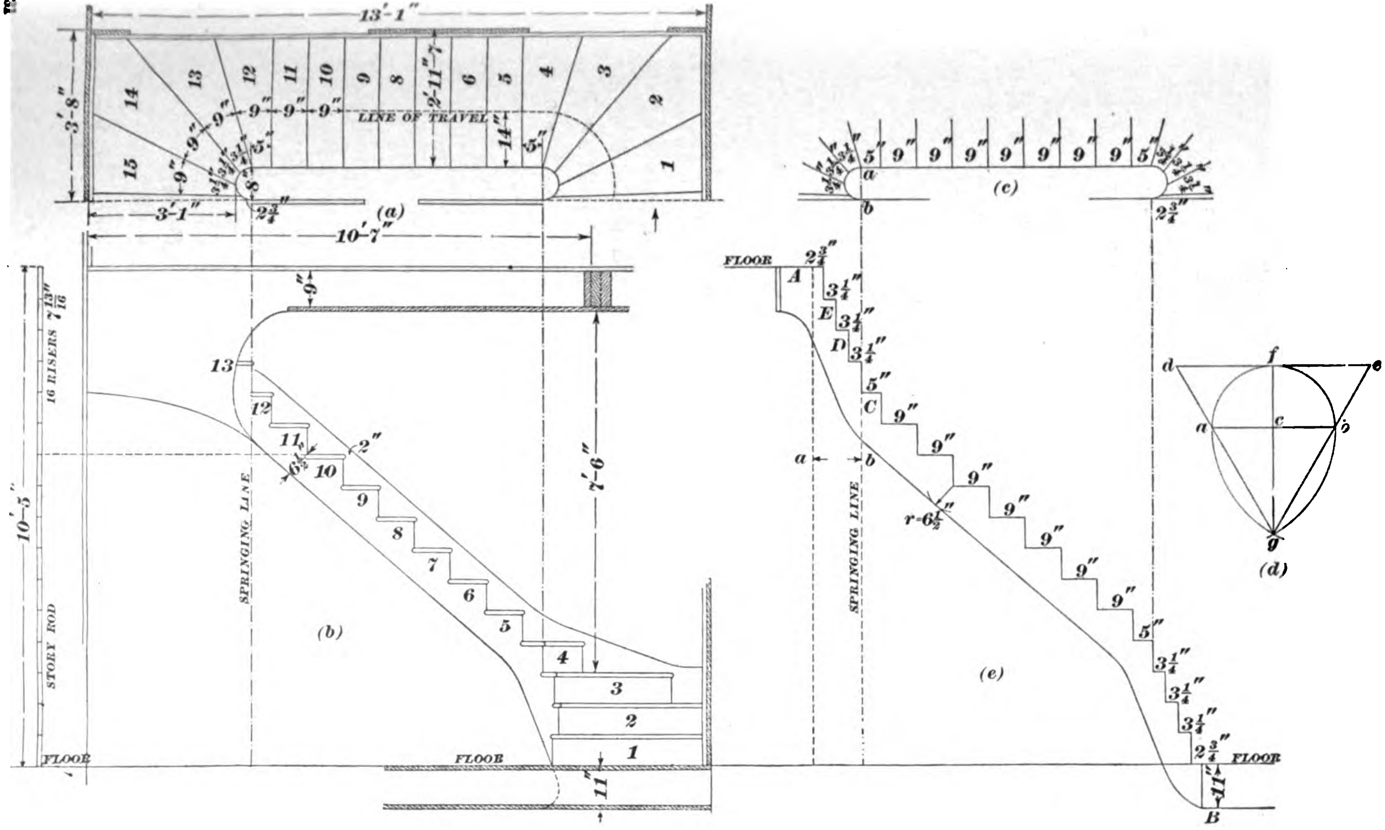
solid work. The front stringer should have a vertical strip 4 inches wide spliced and glued to it, so as to receive the winders. The well must be framed wide enough to include, besides the figured width of the stairway, the thickness of the enclosing lining.

34. Double Winders.—In Fig. 23 is shown a stairway winding one-quarter turn at the top and the bottom, with an 8-inch cylinder for a continued hand rail. In planning winding stairways, it is important to make the treads as nearly as possible of the same width on the line of travel. This line should be about 14 inches from the face of the stringer, as shown on the plan (*a*). The width between finished walls for this stairway should be at least 6 feet 4 inches, as follows:

Width of stairway from finished wall . .	2 ft. 10 in.
Diameter of cylinder	8 in.
Hall passage	2 ft. 10 in.
Total	6 ft. 4 in.

The distance from the finished wall to the cylinder is made 3 feet 1 inch, so as to allow room for moving furniture. Where the stairway is continuous, the first and last risers of each flight should be placed 2 inches beyond the landing fascia line, in order to make a proper finish with the fascia.

In commencing the drawing, the starting and landing risers are marked on the plan, and the line of travel is divided equally, as before mentioned. Then, the space along the cylinder is divided; and, lastly, the risers along the straight stringer are drawn in position. Lines are drawn through the points found along the line of travel and passing through the points located along the front stringer, thus completing the plan of the stairway. The elevation (*b*) of the stairway is drawn by projecting the lines of the risers down from the plan and by drawing the lines of the treads horizontally from the story rod, as shown at tread *10*. For the development of the wall stringer, the method given in Fig. 22 should be followed. The headroom, as shown in



13'-1"
3'-8"
15
14
13
12
11
10
9
8
6
5
4
3
2
1
9"
9"
9"
9"
9"
9"
5"
14"
2'-11"
LINE OF TRAVEL
3'-1"
2¾"
8"
(a)
10'-7"
10'-5"
16 RISERS 7 13/16"
STORY ROD
FLOOR
9"
7'-6"
2"
6½"
11"
SPRINGING LINE
(b)
FLOOR
(c)
a
b
2¾"
3¼"
5"
FLOOR
A
E
D
C
B
r-6½"
SPRINGING LINE
(e)
d
f
e
c
(d)
g

Fig. 23

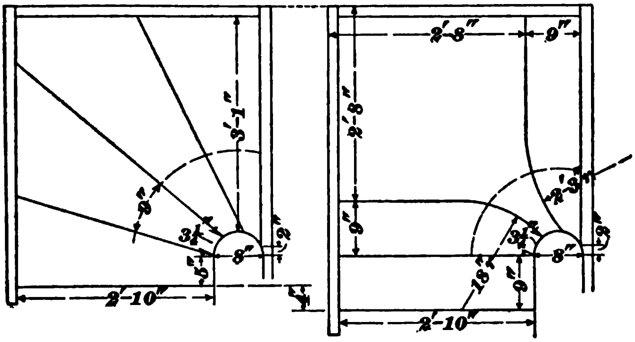
Fig. 23 (*b*), is 7 feet 6 inches from the top of the third step to the ceiling.

35. Width of Winders.—The winding treads must be made of uniform width around the cylinder, so as to obtain a uniform curve in the rail. It will be observed, in Fig. 23 (*a*), that there is a 5-inch width introduced between the straight flight and the cylinder, which provides for a better easement, or ramp, from the pitch of the straight rail into the steeper pitch of the wreath rail; besides, if the winders were all contained in the cylinder, a sudden and abrupt change of inclination in the stairway would be made, thus causing one to stumble and fall.

36. Development of Stringers.—In Fig. 23 (*c*) and (*e*) are shown the methods of developing the front stringer when each end curves around a cylinder. The plan (*c*) of the front stringer is the same as in (*a*). The distance *a b* in (*e*) is equal to the "layout" of the semicircular cylinder, found as in (*d*), where *d e* is the *outstretched*, or developed, length of the curve *a f b*. The length of *d e* may be determined as follows: Make *a b* equal to the diameter of the cylinder. From *c*, with a radius equal to one-half of *a b*, describe an arc *a f b*; from *a* and *b* as centers, with a radius equal to *a b*, describe arcs intersecting in *g*. From *g*, through the points *a* and *b*, draw lines *g d* and *g e*; through *f* draw a line tangent to the arc and parallel with *a b*. The points where this line intersects with the lines drawn through *g* will define the length of *d e*, or the developed length of the arc *a f b*.

A C B in (*e*) is the front stringer, any outstretched step, as *C*, being obtained by projecting the line of the riser vertically from the plan, and the tread horizontally from the story rod. As the steps *D*, *E*, etc. in the cylinder have their width marked on the plan as 3¼ inches, that width is therefore transferred to the development. The stringer in this case is 6½ inches, measured from the angle between the treads and the risers. This width is marked out with compasses from each angle, and a pleasing curve is drawn tangent to the arcs, as shown. When a cylinder is of this diameter, or smaller, at the bottom of the flight, the curve of the hand rail presents a better appearance, and it is more convenient when the rail over the regular treads is continued on its pitch into the wreath without ramping the straight rail. In this case there would be an easement introduced between the straight rail and the wreath piece.

37. Arrangement of Winders.—In Fig. 24 are shown the plans of two different stairways brought together for comparison, each having one-quarter turn with an 8-inch cylinder and a continued hand rail. It will be seen that a platform is obtained by the arrangement shown in (*b*), thus making the flight much more desirable. In the plan (*a*) there are four winders, differing but little from the plan shown in Fig. 23; while in (*b*) there are three winders with slightly curved ends. The five risers so changed in their arrangement in (*b*) take 4 inches more run than the plan with four winders, as shown. The placing of the carriage timbers in such stairways is a matter that requires care, as the strength and stability of the stairway depends largely thereon.



(*a*) (*b*)

FIG. 24

38. Carriage Timbers.—In Fig. 25 is shown the plan of the top winders of a stairway similar to that shown in Fig. 23, *a*, *b*, and *c* being the principal timbers in position.

The timber *a* is set in place after the stringers are put up, being nailed to the floorbeam at *d* and fastened to the wall at *e*. A piece of furring strip held in the direction *e d*, together with a straightedge tried along the line of the risers, will indicate the best position for this timber.

The bottom of the flight, as shown in Fig. 26 (*a*), may be timbered by securely placing a level piece *f k* extending from the front stringer into the wall, and then the two timbers *g h* and *l m* at a steeper pitch than the main timbers *n* and *o*. To do this may require the insertion across the well hole of the floorbeam *j i*; this is shown by the elevation at (*b*), where *l m* and *g h* of the plan are seen at *g′ h′*, and *n* and *o* at *n′*. Or, instead of timbering in this manner, omit the level piece *k t* and place a diagonal timber *i k* at the top, continuing the principal timbers *n* and *o* to meet it. The remaining timbers are filled in as required for furring, which must be done so

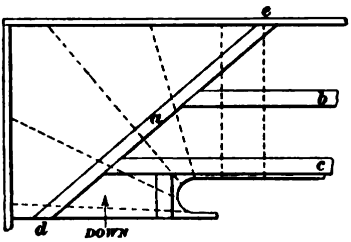
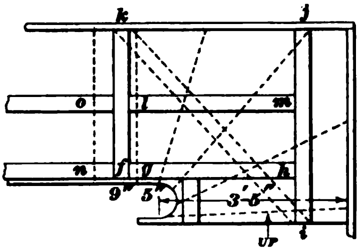
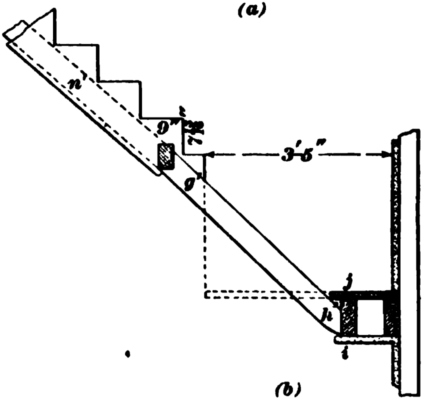


FIG. 25



(a)



(b)

FIG. 26

as to allow the lath to be nailed on in the direction of the risers. In order to obtain a smooth, curved surface on the soffit—which will be more or less warped—care must be taken to aline the blocking by means of a guide lath. In lathing so placed, care should be taken that space is allowed at all points for riveting the plaster, which, under stairways, is subjected at times to jarring that is likely to loosen it unless well keyed or riveted.

NEWEL STAIRWAYS

39. In Fig. 27 is shown a plan of a **quarter-platform open-stringer stairway** with 4-inch square newels framed

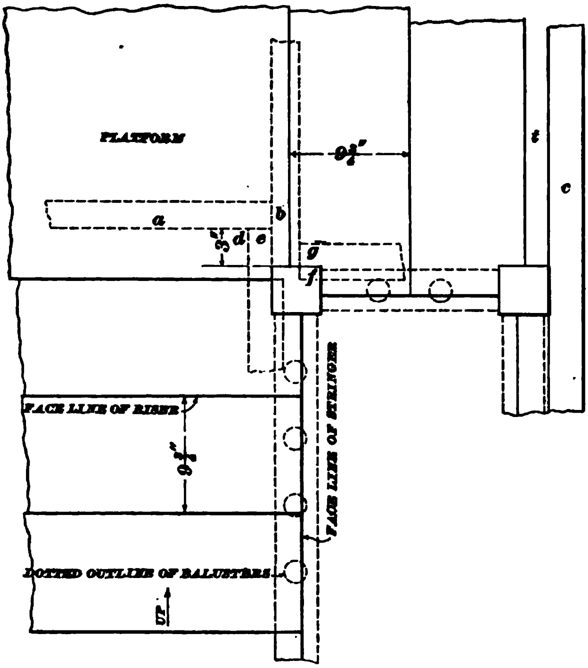


Fig. 27

in the angles, the hand rails making straight connections with the newels, as shown in Fig. 28. The position of the platform beams *a* and *b* and of the floorbeam *c* at the landing,

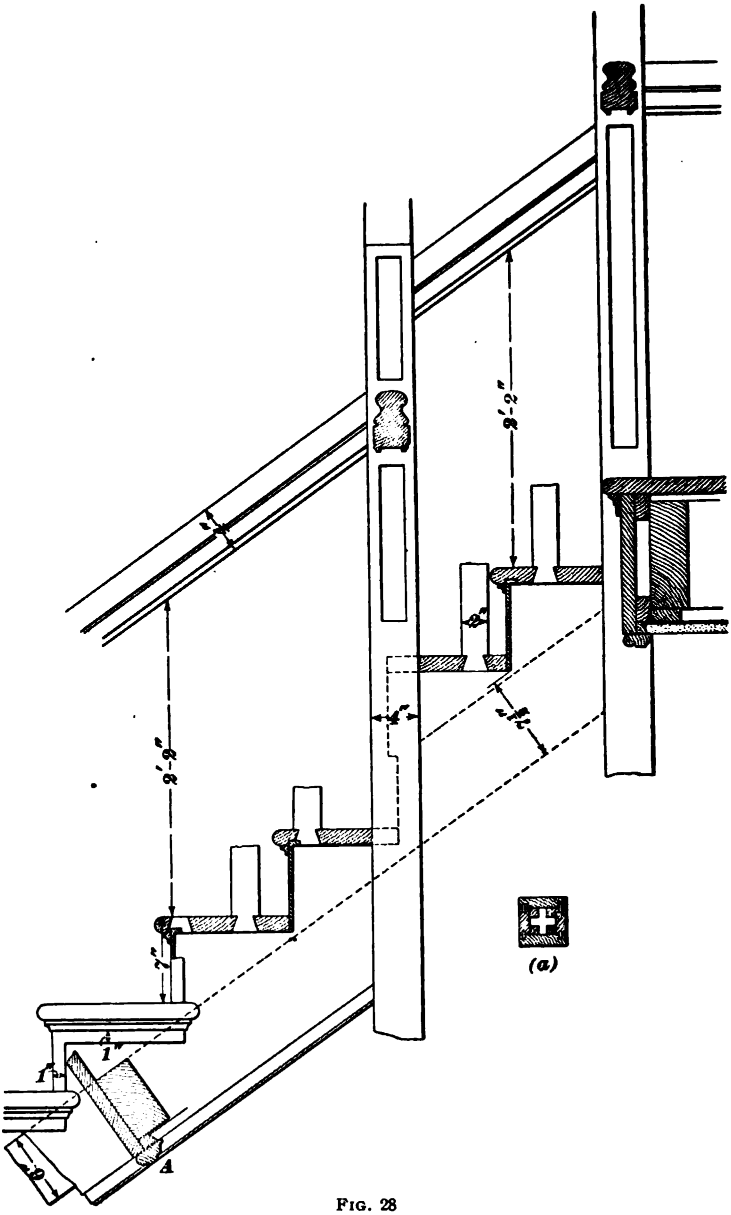


FIG. 28

Fig. 27, should be such that a good bearing is secured for the carriage timbers at *d*, *e* and *f*, *g*. The platform beam *b* should be brought forward to give a support of about $\frac{3}{4}$ inch for the newel.

The elevation, shown in Fig. 28, is projected from the plan, and shows the relative position of the newels, hand rails, balusters, and step trim; the latter is composed of $1'' \times \frac{1}{4}''$ fillets, nosing, and scotia. The newels are built up as shown in Fig. 28 (*a*), slip tongues being inserted into grooves in the sides, and the whole properly glued and blocked. The blocks are first glued to the two narrow sides of the newel, and when dry are planed square with the edge of these pieces. The whole is then heated in a hot box, and the blocks, edges, and slip tongues are glued and brought together with handscrews.

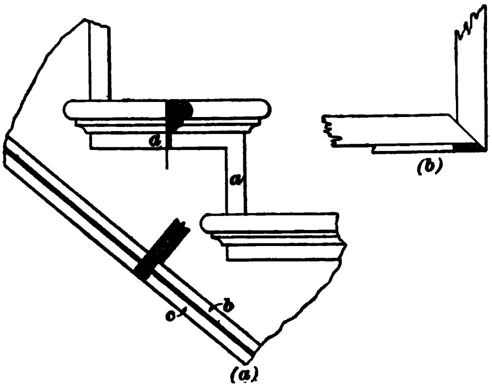


FIG. 29

40. Open Stringers.—In Fig. 29 are shown an elevation and a section of an **open stringer**, where fillets are used. At (*a*) is a portion of the stringer showing the step trim with fillets *a*, *a*. The lower portion of the stringer is relieved to form a fascia *b*, and the edge *c* is formed into a quirk bead against which the plaster finishes. While frequently adopted, this method does not give nearly so good a bond for the plaster as does the soffit mold shown at *A*, Fig. 28, in which the edge of the stringer is kept square.

In Fig. 29 (*b*) is illustrated a section of the fillet, mitering with the riser, which shows that the face stringer must be kept back the thickness of the fillet, in order that the latter may miter properly with the riser.

41. Close Stringers.—In Fig. 30 are shown a plan (*a*) and an elevation (*b*) of a quarter-platform stairway with four risers in the flight adjacent to the landing, close-paneled and molded stringers, 6-inch square newels, 2½-inch turned and square-base balusters, and a 4″ × 4½″ double-molded hand rail, having a ramp-and-knee, or goose-neck, connection with the newels. In the plan, *a* and *b* are the principal floorbeams of the platform, and *c* is the top-landing floorbeam. In drawing the elevation, the first step is to locate the treads and risers as shown by the dotted lines. The balusters may be placed at any distance apart that is desirable on close stringers, as their relation to the treads is not noticed. On the plan is shown the relation of the balusters with reference to the newels, from which measurements should be taken.

Observe, in the elevation of the lower newel, that there are two risers at right angles to each other at the center of the newel, one riser extending from the top step of the lower flight to the platform, and the other from the platform to the first step of the short flight, as shown at *d e f*. In this figure, the portion $d h e' h''$ is the elevation, or side view, of the short flight from *d* to *e* on the plan (*a*). A cross-section of the close stringer, illustrating the panel, timbers, blocking, etc., is shown at *D*, and from this the connections with the newels are lined in as indicated. The section *H* along the floor level is the same as at *D*, but should it prove to be too high above the floor at any time, the panels may be reduced in width. Panel work of this character may have stiles at newel connections, and muntins at suitable intervals in the long flights and landing fascias.

42. Half Newels.—In neweled stairways, the rails should always finish against a half newel at the wall connection, and the lower ends of the half newels may be shown below the soffit. Where half newels are placed on the walls

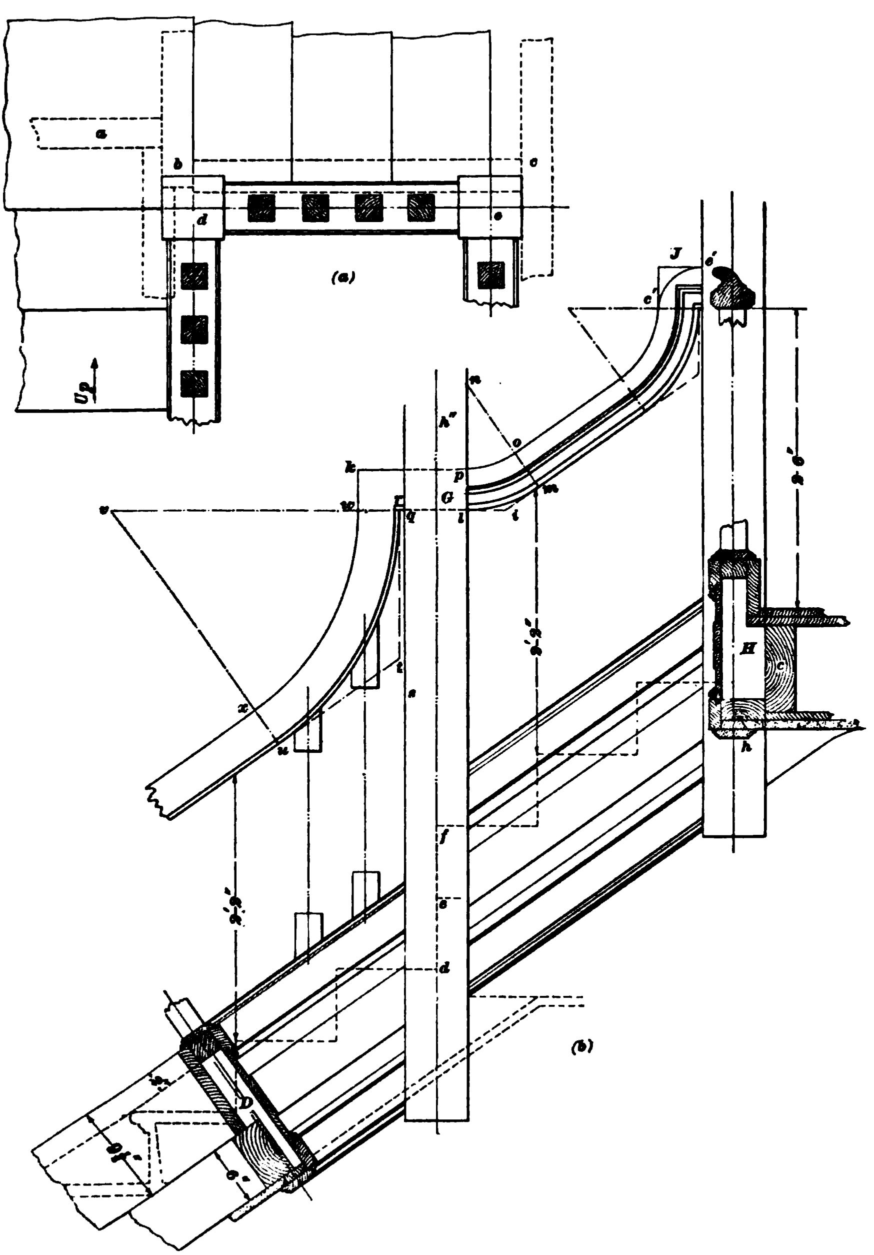


FIG. 30

opposite the platform newels, ornamental flat-arch spandrels may be framed between each newel and half newel, thus finishing the soffit of the platform.

43. Newel Posts and Rails.—The length of newel posts is governed by the depth of the stringer, including the soffit molding. Fixing the height of the easement at G, Fig. 30 (*b*), and the height of the level hand rail at J, the height of the hand rail up the flight is figured, and the rail is made parallel with the line of the stringer. There is nothing important in the position of G, except that it fixes the level of the knee at k.

To produce a good easement, draw the horizontal line $l\,i$ at the required height of the easement and continue the bottom line of the inclined rail until it intersects this horizontal line. Lay off $i\,m$ equal to $i\,l$, and draw $m\,n$ perpendicular to $i\,m$. Let $m\,o$ equal the thickness of the hand rail; from n as a center, describe the easement lines $o\,p$ and $m\,l$. For the ramp and knee, make $q\,r$ from ½ to 1½ inches; perpendicular to $q\,s$, draw $r\,v$, which is a continuation of $i\,l$. Draw $r\,t$ parallel with the newel, and continue the bottom line of the rail until it intersects $r\,t$; make $t\,u$ equal to $r\,t$; from u draw $u\,v$ at right angles to $t\,u$; make $r\,w$ equal to the thickness of the rail; and draw $w\,k$ parallel to $q\,s$. With v, the intersection of $r\,v$ and $u\,v$, as a center, describe the arcs $r\,u$ and $w\,x$. The ramp and knee at the upper landing are defined in the same way. The rail may be curved as indicated by the arc $c'\,e'$, forming a goose neck.

44. Special Arrangement of Newels.—In Figs. 31 and 32 are shown a plan and an elevation, respectively, of a quarter-platform stairway having a quarter-cylinder connection to the landing, thus avoiding the use of a second newel.

45. In Fig. 33 are shown a plan (*a*), an elevation (*b*), and a development (*c*) of a straight stairway, with a single newel set diagonally at the landing, the stringer fascia and hand rail being curved to enter two adjacent faces of the newel. In the plan, $a\,b\,d\,c$ is the position of the carriage

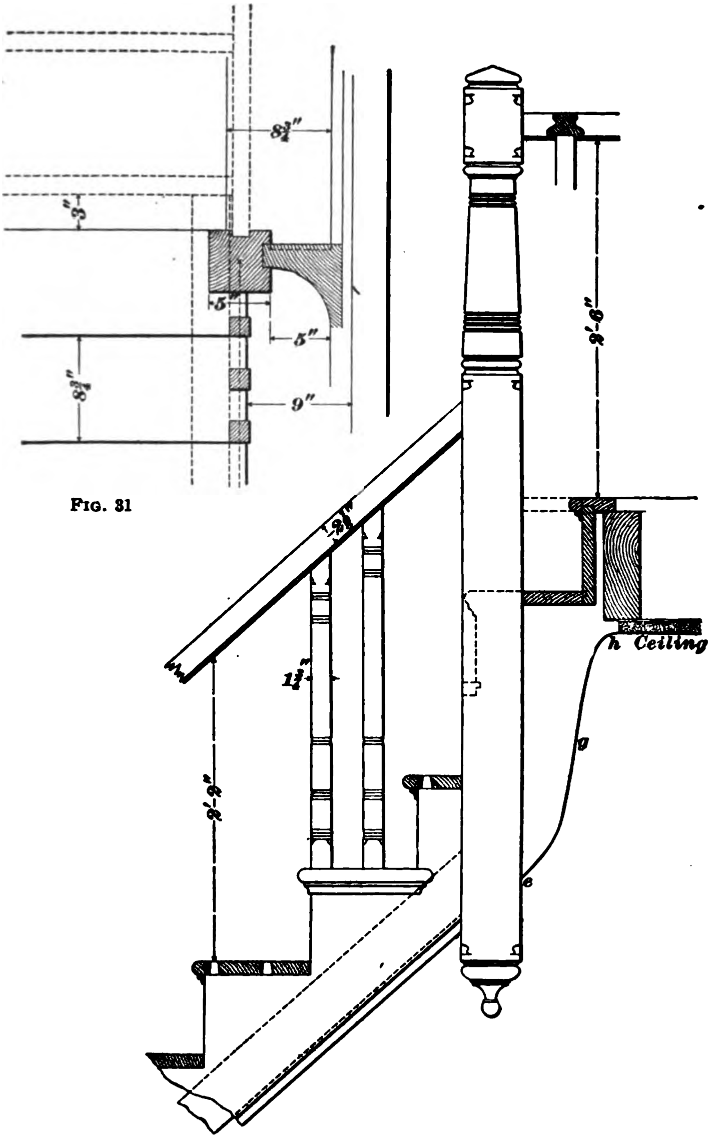


FIG. 31

FIG. 32

timber, and A and B indicate the position of the floorbeams. Half balusters are set against the sides of the newel, to which the hand rails are connected. In the elevation, a', b', d', c' show the depth and position of the carriage timbers, and A is the landing floorbeam.

In the development (c), lay off from the face of the riser $s'e'$ equal to the corresponding distance on the plan, designated at os; then, lay off $e'h'$ equal to the arc sh on the plan;

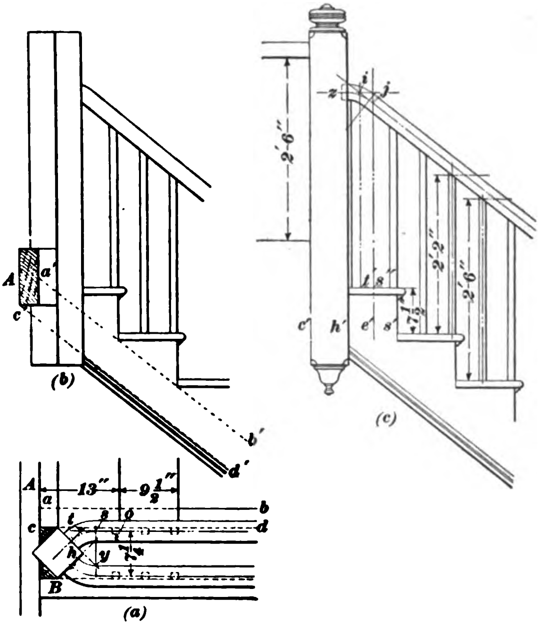


FIG. 33

through h' and c', erect perpendiculars for the sides of the newel; through e', draw $e'j$ parallel with the face of the newel; lay off $s''t'$ equal to st on the plan; parallel with $s''j$, draw $t'i$; from the point where this line intersects the center line of the inclined rail, draw iz parallel with the tread, then jiz is the center line of the rail. This fixes the height of the flight rail at the newel; the level rail is 2 feet 6 inches above the floor. The easement curve at the top of the rail is entirely independent of the horizontal curve on the plan, and may be determined by laying off equal tangents on each side of *i* and erecting perpendiculars to the respective tangents. The point of intersection of these perpendiculars is the center for the easement curve *zj*.

The horizontal curve in the plan is determined by laying off *ts* equal to *th* and drawing perpendiculars *sy* and *hy*. Then, *y* is the center for the curves of the rail and stringer.

46. Swelled Steps and Curved Stringers.—For a pleasing effect, the start of a stairway is often widened by curving the front stringer and increasing the width of several treads by curving the risers. Fig. 34 shows a plan of such a stairway and a development of the stringer and rail. To find the height at which the rail enters the newel, draw the bottom line of the rail through the points where the centers of the short balusters would occur, as at *dd'*; set off from *dd'* the thickness of the rail, 2 inches, and draw the center line of the rail *ef*. The tangents *ck* and *ca* are equal, and *k* is the point where the rail joins the newel. Make *gf* equal to *mk*, draw *co* vertically, and through *o* draw *hj* at right angles to *co*. If the rail is brought to a level on *oj*, its height will be 10 inches above the bottom step *pq*. In this development, the rail is below its real position a distance equal to the height of a short

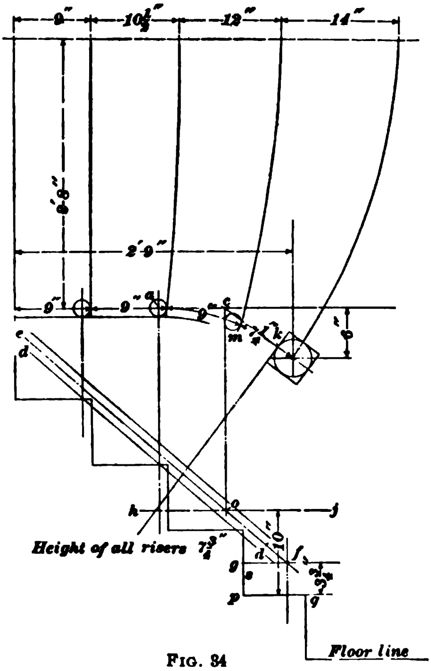


FIG. 34

baluster, or 2 feet 2 inches. This distance added to 10 inches gives 3 feet as the distance from the first step *p q* to the center of the rail at *h j*. If the rail is without an easement to the newel, as at *f*, its height will be 2 feet 5¾ inches.

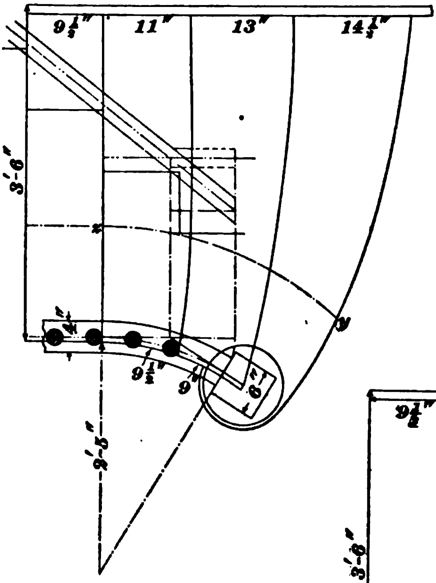


Fig. 35

47. In Fig. 35 is shown a stairway starting at the newel with a curved stringer and swelled steps. The newel in this arrangement is to stand on the first step, the riser extending around to the stringer, which will receive it. Thus, the newel does not project beyond the line of the first step, and, where the space is limited, this method will help to overcome the difficulty. The height of the newel in this case may be determined by the method explained for Fig. 34.

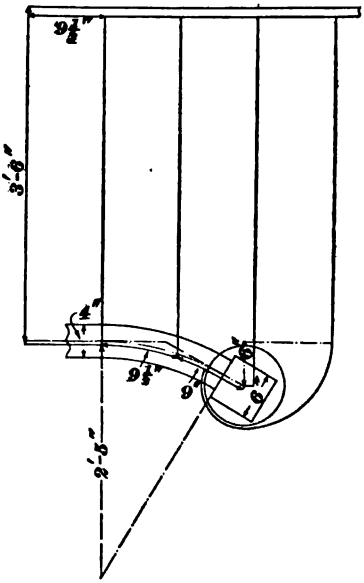


Fig. 36

In Fig. 36 is shown a plan wherein the stringer is curved as in the previous examples, but, with the exception of the starting one, the risers are made straight.

48. Curtail Step.—In Fig. 37 is shown a method of describing the curves of a **curtail step.** Begin by drawing a circle of a size greater than that necessary to enclose the required scroll. Let *a b c d* be such a circle; divide it into sixteen equal parts, and let the diameter of the eye of the scroll be equal to *e f*, in this case 7 inches. The diameter of the eye should always be somewhat greater than the width of the hand rail, which in this case is 6 inches. At right angles to *b d* and tangent to the eye, draw *e' i*; from *i*, draw *i j* perpendicular to *h g*; and so proceed, drawing lines at right angles to the successive radial lines. This process may be continued to *m* or to any point desired. From the points of intersection *m*, *n*, etc. on the radial lines, with a radius equal to 3 inches, or one-half the width of the rail, describe circles as shown until one is tangent to the eye, as at *x*. From here each successive circle is smaller, so as to be tangent to the eye. Tangent to these circles, draw in an outline of the curve of the hand rail.

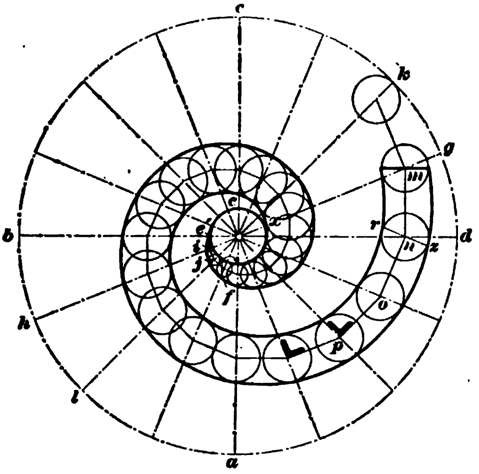


FIG. 37

49. In Fig. 38 (*a*) is shown a plan of the curtail step with curved steps receding from the same. This plan may be drawn from the dimensions given, taking as much of the scroll delineated in Fig. 37 as is required to fulfil the conditions. At *z r*, Fig. 38 (*a*), is shown the junction of the scroll with the straight rail. Where the scroll has been developed in a diagram, as shown in Fig. 37, the whole or any part of it may be transferred to the plan of the stairway, as was done in Fig. 38.

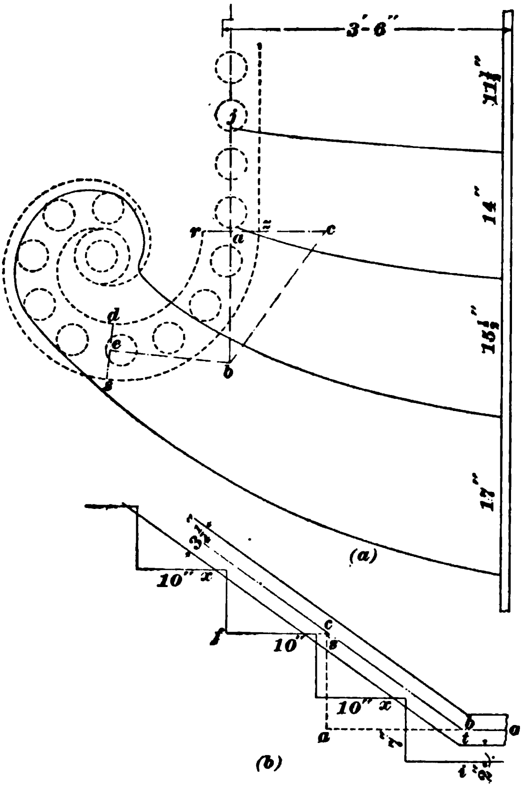


FIG. 38

In order to fix the height of the wreathed portion of the scroll, draw an elevation of the risers and treads as at (*b*). Draw the bottom line of the rail *x x* through the points on the treads where the center lines of the short balusters intersect; then, draw the center line *c b* of the rail, and make *f s* equal to *j a* in (*a*). Parallel with the riser lines, draw *c a* through *s*, and make *t i* equal to, say, 2 inches, thereby fixing the height of the eye and the level portion of the scroll. Make *t b* equal to one-half the depth of the rail, and draw *b a* parallel with the tread line. Then, as the bottom line of the scrolled rail is 2 inches above the first step *i*, and the length of a short baluster is 2 feet 2 inches, the height from *i* to *t* will be 2 feet 4 inches, when the rail is in position. The scrolled rail should be kept as low as that shown, so that its varying and pleasing curvature will be seen to the best advantage.

In the plan, Fig. 38 (*a*), *a b* is the center line of the rail prolonged, and *a c b* is taken from lines similarly lettered in (*b*). From *b*, draw *b e* tangent to the center line of the rail at *e*. The joint *s d* is made at right angles to *e b*. From *s d* to *z r* is the wreathed portion of the rail, since it both curves and rises. The remaining portion of the scroll, from *s d* to the eye, is horizontal, as shown by *b o* in the elevation (*b*), and in this part of the scroll, three or four of the balusters should be bolted at their bases to the step and at their tops to the scrolled rail.

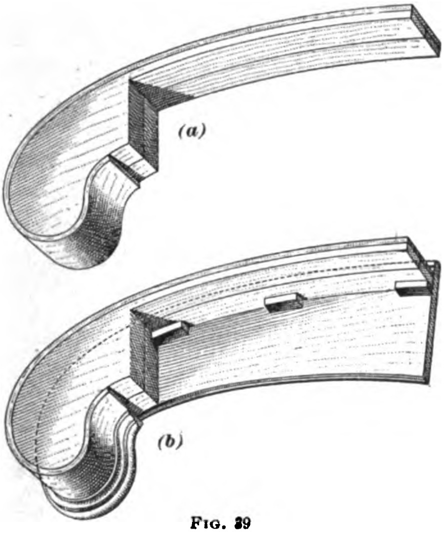


FIG. 39

The construction of the veneered riser and scroll block is shown in Fig. 39 (*a*), and the complete scroll step is shown in (*b*).

SPECIAL FORMS OF STAIRWAYS

50. Quarter-Platform Stairway.—In Fig. 40 is shown a plan of a **quarter-platform stairway** with a quarter cylinder for a continued hand rail. Any radius of cylinder considered desirable may be used, but if the risers *o b* and *o' b'* are put at a distance equal to one-half the width of a tread from the point *a*—the intersection of the center lines of the rail—the wreath piece will conform to the common pitch of the flights. If the front stringer is a close one, and the risers are placed as shown, the effect will be more agreeable than it would be if the risers were placed either nearer to or farther from the point *a*. This arrangement of the risers will allow a graceful curve in the development of the front stringer and the hand rail, while if placed in any other position, the result will be an unsightly crippled rail and stringer.

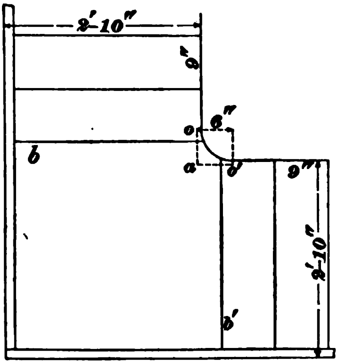


FIG. 40

51. Quarter-Turn Winding Stairway.—The plan of a **quarter-turn winding stairway,** with a quarter cylinder for a continued hand rail and with regular treads above and below, is shown in Fig. 41. It will be noticed that the treads adjoining the cylinder in both flights are reduced. The benefit derived from the reduction will appear in the curve of the rail and the stringer, as it modifies the angle of

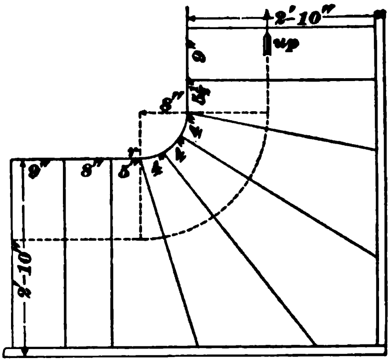


FIG. 41

intersection between the pitch of one straight rail and that over the winders, the stringer, of course, being affected in the same manner.

52. **Platform and Curved Risers.**—In Fig. 42 is shown a plan of a stairway that includes two platforms with a tread and two curved risers in the 10-inch cylinder between the platforms, making a half turn. The wreathed rail over this plan has a pleasing shape, and no ramp is required in the straight rail either above or below the wreath.

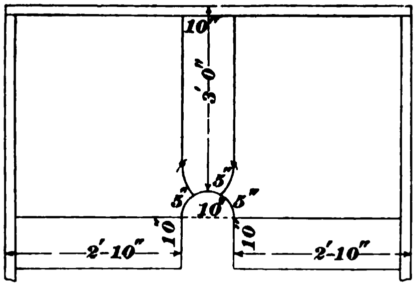


FIG. 42

53. **Newel Between Quarter Cylinders.**—Fig. 43 shows a plan of a stairway with a newel post set between quarter cylinders on the landing of a flight. The hand rail in this case will be bolted to the newel.

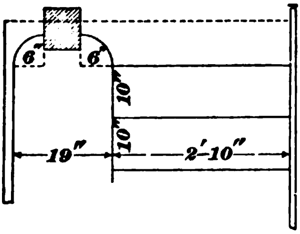


FIG. 43

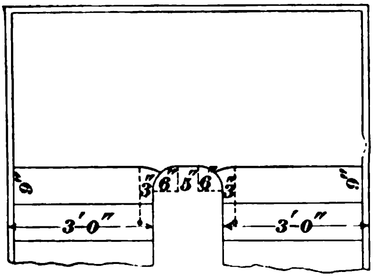


FIG. 44

54. **Half-Turn Platform Stairway.**—In Fig. 44 is shown a **half-turn platform stairway.** The face of the top riser of lower flight and that of the bottom riser of upper flight have a slight curve adjacent to the flattened cylinder. By this method the whole depth of the cylinder is saved in the width of landing, which is an advantage where space is limited.

55. Winding Stairway.—Fig. 45 shows a plan of a **winding stairway** having seventeen risers. The cylinders for this continued hand rail have a diameter of 10 inches.

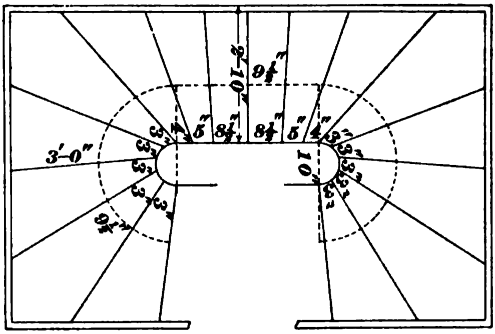


FIG. 45

This arrangement is suitable where space is limited and where the entrance to the staircase is on the side.

56. Arrangement for Intermediate Floor.—Fig. 46 illustrates a plan for the starting and landing of two flights connected by a 12-inch cylinder. Such an arrangement is used where the short flight ascends to an intermediate floor on the platform level.

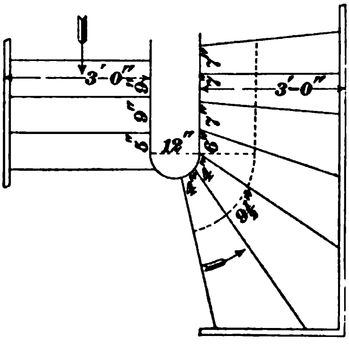


FIG. 46

57. Quarter Platform With Tangent Between Quarter Cylinders.—In Fig. 47 is shown a plan of a quarter-platform stairway for a continued hand rail. The cylinder opening of 18 inches is formed by two quarter circles—each of 5 inches radius—with an 8-inch piece of straight stringer placed between. By this method a platform is secured, and angular winders are dispensed with; the length of the staircase is also reduced.

58. Quarter Platform With Semicircular Cylinder. Fig. 48 differs from the preceding plan only in the form of its cylinder, which is semicircular in plan, and, while requiring a little more run, furnishes a more pleasing rail and cylinder.

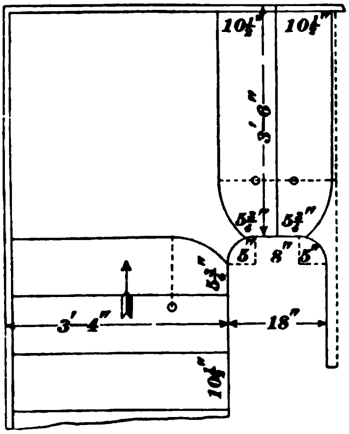


FIG. 47

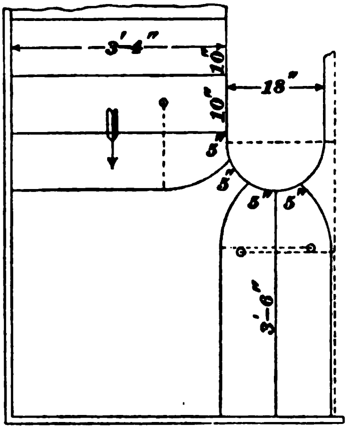


FIG. 48

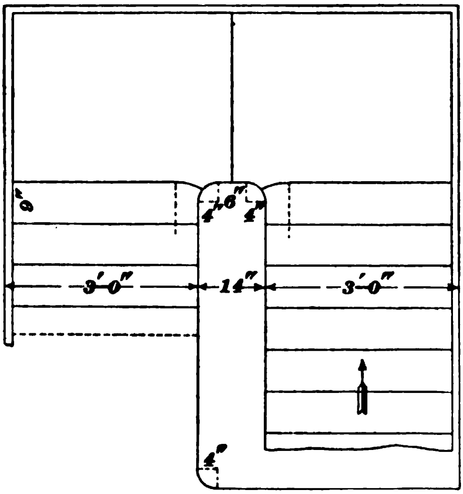


FIG. 49

59. Double Platforms.—Fig. 49 shows a plan of a platform stairway making a half turn, one riser at the center of the cylinder dividing the space into two platforms. Where the run will permit, it is always advisable to dispense with this central riser, thus adding breadth to the platform, and avoiding the danger of stumbling at the step placed where it is not expected.

60. Quarter Platform With Step.—Fig. 50 shows a plan of a quarter-platform stairway with a 15-inch cylinder having a regular step at its center.

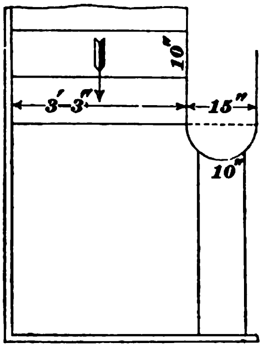


FIG. 50

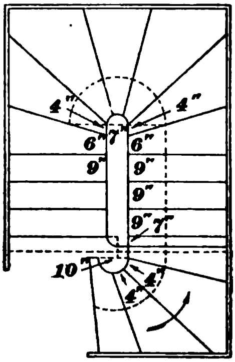


FIG. 51

61. Three-Quarter Turn.—Fig. 51 shows a plan of a winding stairway making a three-quarter turn, the entrance being at one end of the staircase.

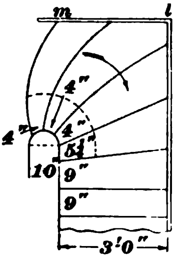


FIG. 52

62. Starting or Landing Winders. Fig. 52 shows a plan of a stairway that has winders either at the starting or at the landing. The curving of the risers is resorted to for the purpose of making them occupy less room from *l* to *m*. Curving the risers in this manner also improves the appearance of the stairway by reducing its angularity.

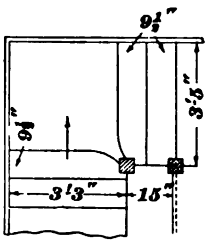


FIG. 53

63. Quarter Platform With Newels.—Fig. 53 shows a plan of a quarter-platform stairway with small newels framed to the stringers in the angles; the hand rail may join the newels either straight, with easements and with ramp and knee, or with a goose neck. The curved risers are introduced to save space in the run of the flights.

64. Platform Stairway With Two Return Flights. In Fig. 54 is shown a plan of a platform stairway with two return, or *wing*, flights, suitable for a public building. The flights and platform may be wainscoted, and, by the introduction of half newels set against the wall opposite the regular newels, a good structural effect is obtained. The regular and wall newels may be carried up as columns and pilasters, further improving the treatment. Flat, ornamental arches may be introduced between the newels and half newels where they extend below the soffit of the platform, to break up and panel the soffit spaces. For a public stairway of this character, in either wood or iron, a better effect is produced by omitting the plaster and showing the framework.

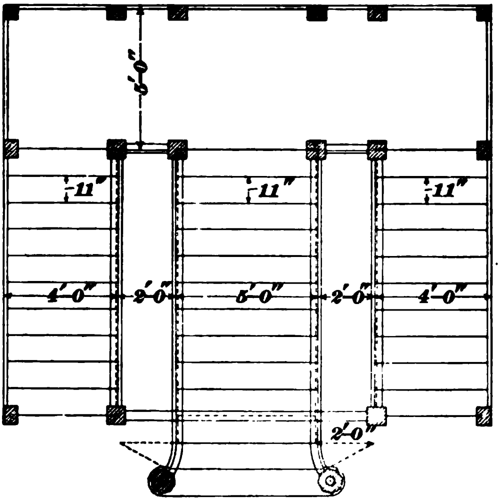


FIG. 54

65. Circular Stairway.—A plan of a **circular stairway** is shown in Fig. 55. All the risers except the three curved ones at the start radiate from the center *b*, and are equally spaced at the front and wall stringers. The front stringer along the first two steps is curved out, to increase the width of the stairway at the start, thus giving it a more pleasing appearance. A curtail step and a hand rail at the starting of such a stairway are very appropriate and attractive. The dotted lines indicate the position of the carriage timbers. A similar method may be followed for elliptic stairways.

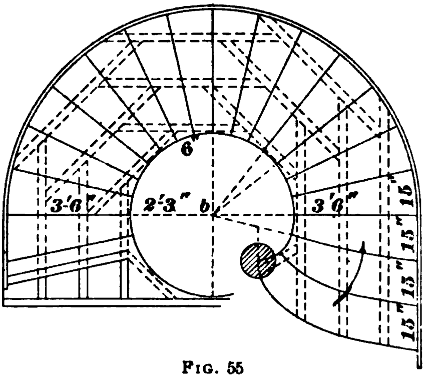


FIG. 55

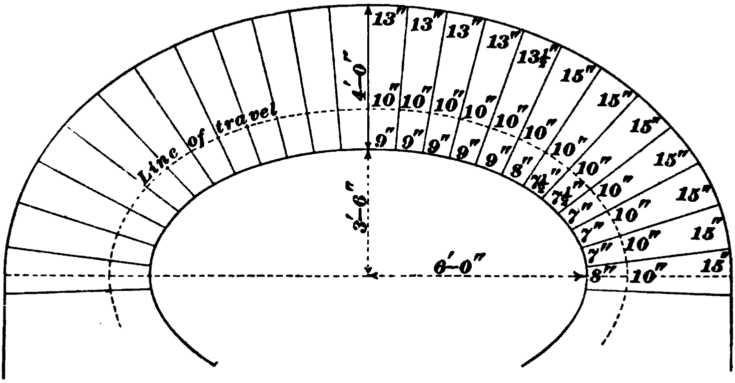


FIG. 56

Instead of a cylindrical front stringer, as in this plan, a circular newel post of sufficient length is sometimes used as a central support, the treads and risers being framed into the central newel and into the wall stringer. The newel post may be cased with $\frac{7}{8}$-inch boards of the same width as the treads at the point of connection, thus affording support and enclosure-like mortises to the steps; the grooves for the risers may also be cut out from the edge of the boards, thereby rigidly securing them. This casing, or staving, however, should not be set in place until all the steps are nailed in position.

66. Elliptic Stairway.—In Fig. 56 is shown a plan of **an elliptic stairway.** The customary method of providing a uniform width for the treads along the wall stringer, and also along the front stringer, causes some of the risers to stand at such an angle with the line of travel as to diminish the width of treads at those points. It has the advantage, however, of giving the hand rail a uniform pitch from end to end.

In another method, shown in the plan, the treads are divided equally on the line of travel, and the risers are drawn as nearly as possible normal to the front stringer.

WAINSCOTING

67. The paneled wall lining for halls and stairways is made of different heights, the arrangement and treatment of the panels being varied to meet the ideas of the designer. In Fig. 57 is shown a portion of wainscoting as it passes from the hall up the flight. A vertical section of the framework, panels, and moldings as usually made is shown at *D*, where *a* is the baseboard; *b*, the bottom rail; *c*, the panels; *d*, the middle rail; *e*, the top rail; *f*, the cap molding; *g*, the base molding; and *h*, the furring strip. In the elevation, *h' h'* is a stile with a groove *j* to receive the return wainscoting; at *k*, *k* are muntins. The stile *h' h'* extends the whole height, and the three rails are framed into it. The panels are square on the level portion, but up the flight they change their shape and become narrower, as the width of the wainscot *n n* is less than the width *m m*.

The curves at the junction of the pitch and level lines are described from three different centers, as shown. The curves cannot be described from a common center, as the two portions are not of the same width. By producing the tangents of the level and inclined portions of the top, bottom, and central rails, and deciding on the length of the curves, radial

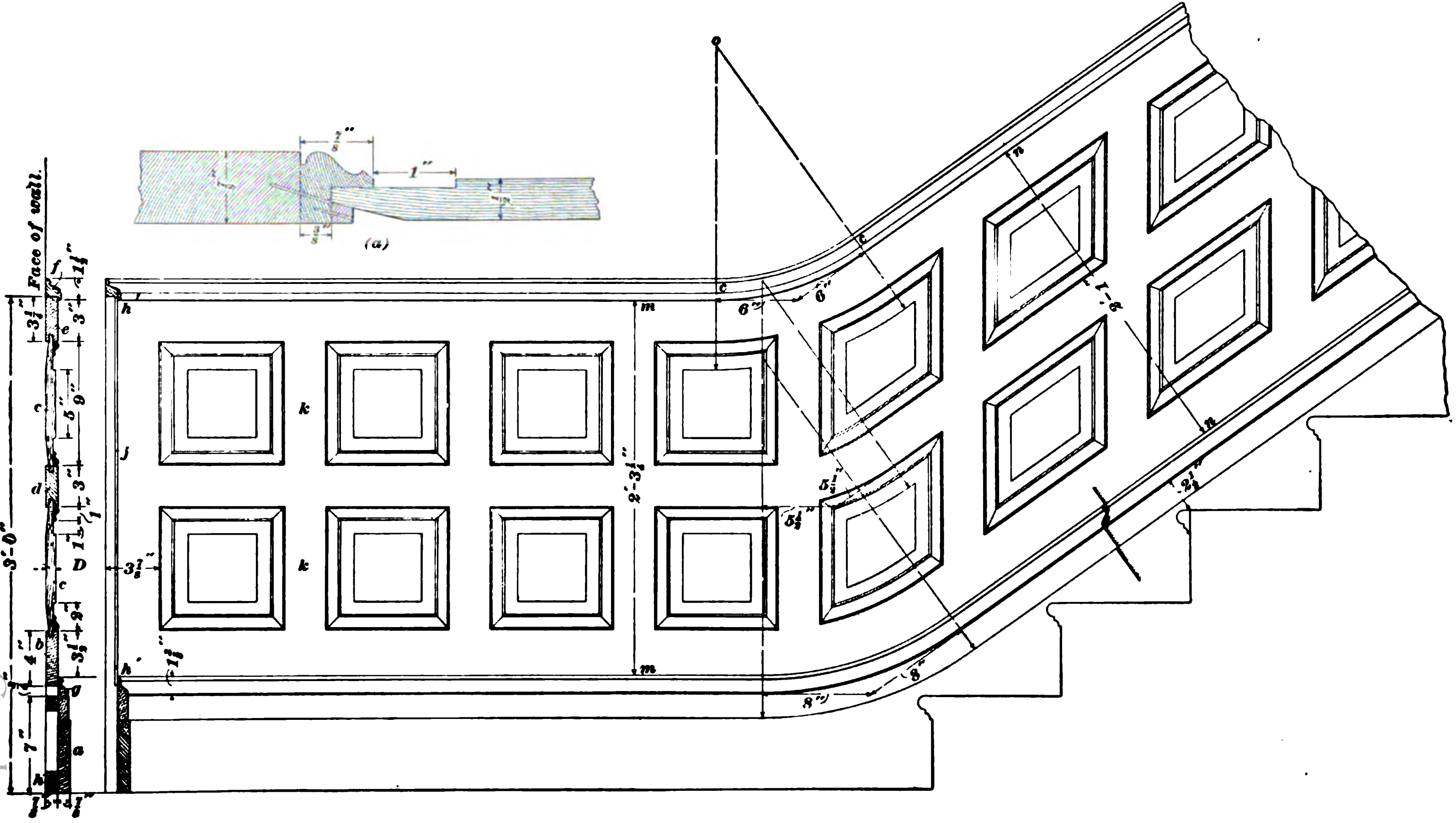

Face of wall.
(a)
1"
7/8"
3/8"
o
c
c
n
n
1'-8"
6"
6"
m
m
2'-3¼"
k
k
h
h'
j
3⅞"
1⅛"
5¼"
5¼"
2¼"
8"
8"
3'-0"
3¼"
3"
9"
5"
3"
1"
1⅛"
D
e
f
d
b
g
a
4"
3½"
7"
1⅛"

FIG. 57

lines may be drawn from the points, as at *c*, *c*, thus locating the center, from which simple curves may be drawn.

At (*a*) is shown a method of fastening the panels so that no nails will show on the face of the molding. The panels are polished separately and put in place after the frame and moldings are finished. The framework should be well seasoned, and the walls should be perfectly dry before the wainscoting is set in position.

ORNAMENTAL METAL WORK

(PART 1)

CAST-IRON WORK

INTRODUCTION

1. Iron is used in building construction to serve two purposes, one structural and the other ornamental; but becomes an element of architectural consideration only when both purposes are combined. Unfortunately, the facility with which iron may be cast or wrought into any desired form renders the execution of the whole façade of a building as simple as though it were constructed of wood, and imbues the ironwork designer with a tendency to ignore the characteristics of the material with which he is working, and to execute columns, capitals, and friezes in cast iron with fidelity to original examples that were carved in stone and whose designs are ill suited to iron.

However, the incombustible character of this material, and the fact that its use materially shortens the time and decreases the expense of erecting a building, render it certain that iron as a building material is as important in the 20th century as was stone before the Christian era; and instead of condemning it as an "unarchitectural material," as some are inclined to do, it is our duty to study its character and possibilities in design and to develop a system or scheme of design that will be consistent with the conditions imposed by the material and its structural use.

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To do this, it will be necessary to understand the method of manufacture and difficulties attendant on the execution of any design in ironwork, so that in preparing a design it can be kept free from impossible demands. For instance, if the design is for a piece of cast-iron work, the designer must provide a means of molding the form properly and of getting the fluid metal into the mold without injuring any of the finer details. If the design is for a piece of wrought-iron work, such as a grille or a railing, provision must be made for enough space to permit riveting, hand welding, etc.

Thus, it will be seen that a careful consideration of the methods used in general shop practice will be the best way for the ironwork designer to advance in the comprehension of his work. This Section will therefore treat of the details of shop and field work in connection with the manufacture of iron for architectural purposes; and, therefore, the illustrations of working drawings used herein to elucidate the text are reproductions of drawings that have actually been used in the preparation of ironwork for some of the most important buildings in the United States.

Within certain limits, all that is necessary to know in regard to patternmaking and molding will be indicated in a general way; but, as in all other industries, new methods are constantly being adopted in working out the details of the various problems as they arise, although the basis of the operations remains the same.

METHOD OF MANUFACTURE

DEFINITIONS OF TERMS

2. Cast Iron.—The material obtained by melting iron ore with coke in a furnace is called *pig iron*. When the latter material is remelted and poured into a suitable receptacle, or *mold*, and allowed to cool and solidify, it constitutes **cast iron**. Cast iron is hard, brittle, and somewhat crystalline in its composition—that is, it shows on its fractured surfaces an appearance resembling an aggregation of small crystals, instead of a fibrous fracture like wrought iron. It is used, architecturally, for columns and newel posts, and, under certain conditions, for lintels or beams; but, owing to its lack of tensile strength, it is not well adapted to conditions of transverse strain. Cast iron is also formed into slabs for the purpose of stair treads, pavements, etc., and some forms of ornament are cast and attached to structural details.

3. Molds are the receptacles into which the molten metal is poured to give it some definite form consistent with the purpose that cast iron is to serve in the building. The molds are made by impressing in sand a cavity or a number of cavities that correspond in shape and relation of parts with the contour of the object to be cast. The process of so impressing the sand is called *molding*, and is effected by means of a wooden, plaster, or metal model of the object, called a *pattern*, which is so embedded in the sand that it will leave its impress when withdrawn.

4. Cores, as the word implies, are those parts of the mold that form the inside of hollow castings, and also means any parts of the sand mold that are made separately and placed within the principal mold. They are made of a mixture of sand and flour, or oil, and with the exception of very small cores, they are usually stiffened by running an iron bar lengthwise through their middle.

5. Casting is the operation of pouring the molten iron through the inlets—or *gates*, as they are called—into the sand mold from which the pattern has been withdrawn. All of the details just described culminate in the casting. The making of the pattern, with its allowances for shrinkage and draft, the preparation of the mold with its gates, and all the details attendant thereon, are for the sole purpose of securing a perfect casting, and all conditions and contingencies must be considered before the metal is poured.

6. Patterns are generally made of wood or of plaster, and occasionally partly of each. Where there are to be a great many castings of one kind, the pattern is sometimes made of bronze or iron, in order to withstand the wear, but even in such cases the bronze or iron pattern would be cast in a mold originally impressed with a wooden or plaster model. Whether a pattern shall be of wood or plaster depends entirely on the character of the work. Patterns for plain straight work, such as molded panels, stair strings, columns, etc., are generally made of wood; but ornamented moldings, decorated panels, complicated capitals, etc. are first modeled in clay or wax, from which a cast is taken in plaster.

All patterns must have an allowance made for *shrinkage;* that is, the contraction and consequent decrease in size that every casting undergoes in the process of cooling. In ordinary work, this amounts to about $\frac{1}{8}$ inch per foot in every direction; so that the patternmaker should use a *shrinkage rule* to lay out his work. The shrinkage rule is usually a little over 2 feet in length and the divisions on it corresponding to 1 foot are in reality 1 foot and $\frac{1}{8}$ inch, and the subdivisions are proportionately excessive. Consequently, the pattern for a cast-iron bar 1 foot long, 3 inches wide, and $1\frac{1}{2}$ inches thick, would measure 1 foot $\frac{1}{8}$ inch long, $3\frac{1}{32}$ inches wide, and $1\frac{33}{64}$ inches thick.

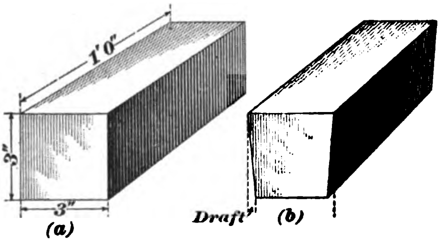


Fig. 1

In order that they may be freely withdrawn from the mold, patterns are worked with a *draft*, or taper. For example, if the object to be cast is a solid bar 1 foot long and 3 inches square in section, as in Fig. 1 (*a*), it will be found, in lifting the pattern from the mold, that the sand has a tendency to cling to the sides and thus destroy the mold; but if the sides of the pattern are slightly beveled, as in (*b*), this tendency will be overcome, and the sides of the mold will be left clean and sharp. Therefore, in every case where it is possible, all surfaces that occupy a vertical position in the mold should have an allowance for draft. The exact amount of this allowance cannot be given, for in some cases there should be as little as possible, while in others it may be quite considerable without in any way impairing either the purpose or the appearance of the part.

7. Undercut work is the term used to describe the shape of any part or parts of the pattern that cannot be removed from the sand without special arrangements being made for that purpose. Whether any member is to be considered as undercut or not sometimes depends on the position of the pattern in the mold.

A casting of the shape and section shown in Fig. 2 (*a*) and (*b*) is not considered undercut, if it is molded vertically,

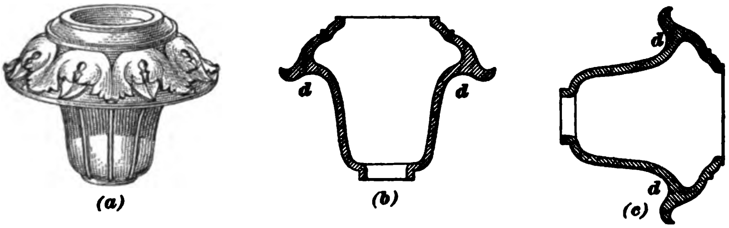


FIG. 2

as here shown and as explained later, but if for any reason this same article should have to be molded in a horizontal position, as in (*c*), the hollows *d* would then make it undercut, as the pattern could not be removed from the mold without carrying away the sand held in the hollows.

8. Modeling and Templet Work.—Sometimes it becomes necessary to make the whole or part of a pattern in clay or wax. Such molding is done by hand, and some of the tools used for this purpose are shown in Fig. 3.

When the molded parts constitute plane or circular surfaces, the hand work may be made less difficult by means of templets, mostly in connection with molds in plaster of Paris. This is largely done by drawing templets over the plaster while in a soft condition. These templets are usually made of thin plates of zinc that are cut out to the shape of the molding or whatever is to be formed in plaster. To strengthen and keep the templets from bending, they are backed with wood.

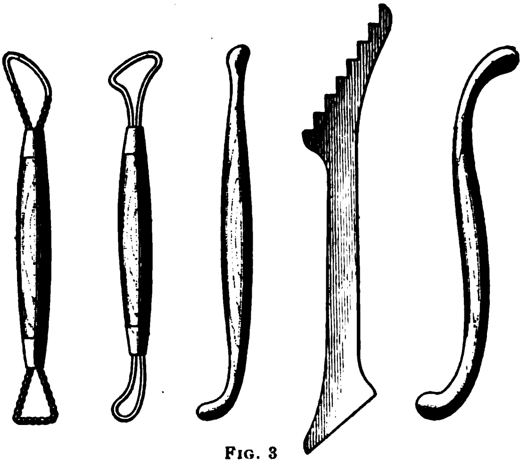
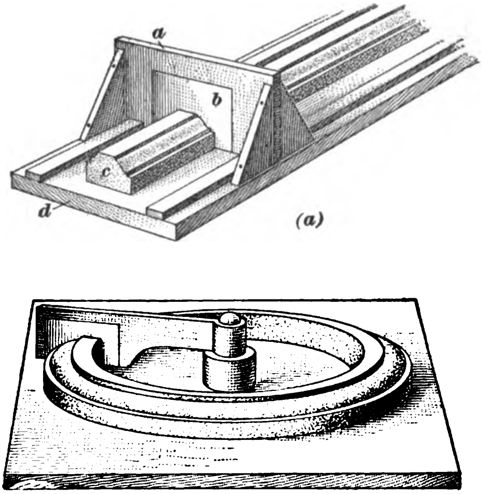


FIG. 3



(b)

FIG. 4

Fig. 4 (*a*) shows a templet *a* with the zinc part *b* resting on a board *d*. The plaster molding that has to be run up is shown at *c*.

If the molding is required in the shape of a ring, the operation is similar, but the templet is worked from a central pivot, as shown in Fig. 4 (*b*).

9. Shell Patterns.—If the casting is to be made of thin metal, the pattern, which is called a **shell pattern,** is made on a supporting block or bed, sometimes called a *match.* The match, shown in Fig. 5, is made of plaster of Paris *a* and a wooden frame *c*, the latter being used simply to protect the plaster of Paris. The inside of the pattern, which is made of plaster, is shaped on the match with a zinc templet. After becoming hard, the plaster is oiled and varnished, so that the pattern will not adhere while being made. More plaster is then applied and this is swept with another templet made to conform with the outside of the pattern, which completes the model, as shown at *b*. The pattern is then allowed to remain until it has hardened, after which it is removed.

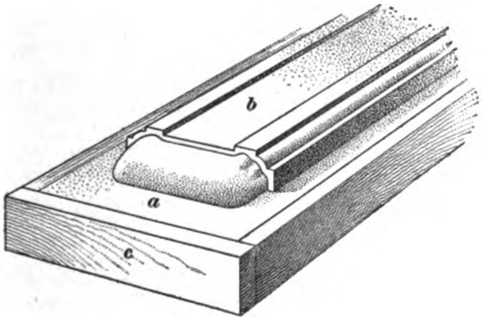


FIG. 5

The match is also used in place of a follow board when a pattern is being rammed in the mold. A pattern, as shown, might possibly be part of the trim around an entrance, in which case the ends would be cut and mitered to form the corners in the same manner as a wooden casing.

10. Patternmaking.—Before describing the process of molding, it is necessary to know more about how patterns are made. A few typical examples will illustrate this in a general way. When the object is of a flat nature, such as a panel or fascia, Fig. 6, the pattern may be either of wood or of plaster.

If there is any ornamental work, as at *a*, the decoration is modeled in clay or wax and then planted on the pattern.

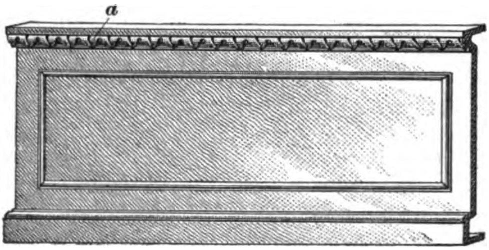


FIG. 6

If the casting is to be hollow, as, for example, the newel post or short column with open ends, shown in Fig. 7, the pattern might be a shell in two halves, joined diagonally and supplemented by a *core box* with which to mold the sand core in order to form the hollow in the finished casting. The making of core boxes will be described further on. In this case, it is assumed that the decoration is in low relief and not undercut. In making this pattern, the body of one-half would be made of wood or plaster and the modeled ornament planted on. From this original pattern, the halves are molded in plaster and used as the working pattern.

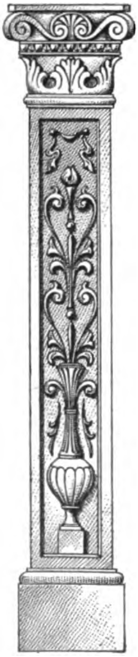


FIG. 7

11. Molding.—The making of molds of various shapes into which molten metal is poured to form different objects is termed **molding.**

The tools used for molding are shown in Fig. 8, and include the rammer with which the sand is pounded into the box and several other implements that are employed to smooth and finish the sand after the pattern is removed. The names of these implements are given in the illustration.

The boxes containing the molds, called *flasks*, are made of either wood or iron. In cases where great numbers of similar castings are to be made, iron boxes are preferable. Fig. 9 illustrates an ordinary iron box with toothed cross-ribs, to bind the sand and prevent it from dropping out by its own weight. The pins *c*, fastened to lugs d_1 on the lower half *b*, fit into holes in lugs d_2 on the upper half *a*, thus fixing the relative position of the two halves. When the mold is complete, the two parts are held together with clamps.

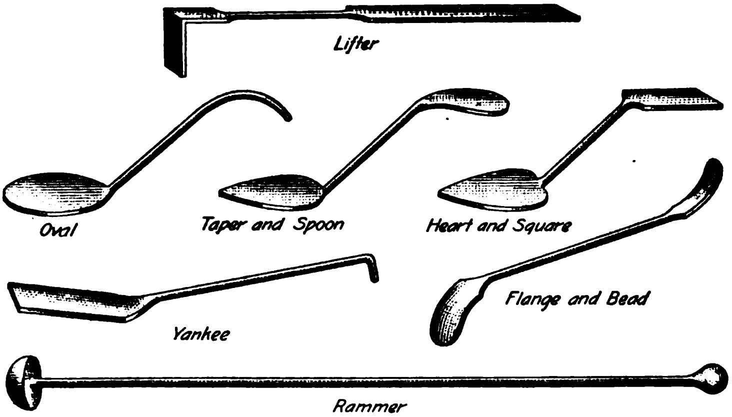


FIG. 8

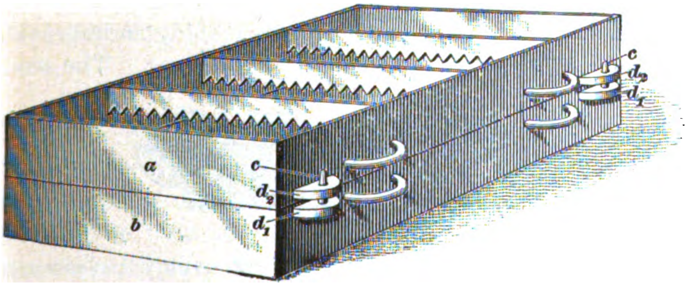


FIG. 9

12. Examples of Molding.—The method of molding a flat panel or fascia, which is shown in Fig. 6, is as follows: The pattern to be molded is first laid face upwards on a board, known as a *follow board*, and then half of the flask, called the *drag*, is placed over the pattern and securely clamped to the board. Sand is then put into the box and firmly tamped down all around the pattern, as in Fig. 10 (*a*). Both box and board are then turned over, as shown in Fig. 10 (*b*), and the board is removed, leaving the pattern uncovered, after which a special dry sand, known as *parting sand*, is sprinkled over the face of the mold. The upper half of the flask, called the *cape*, is now clamped on top and sand is filled in as before, but this time two or more tapered wooden plugs are put in, extending from the pattern to the top of the cape. After the mold is made, these plugs are withdrawn, and the cavities that result make gates and risers for the metal. The top part of the box is next removed and the pattern is withdrawn, leaving an impression of its face in the drag and its back in the cape. The use of parting sand makes the mold separate evenly between the cape and the drag, without disturbing the casting sand.

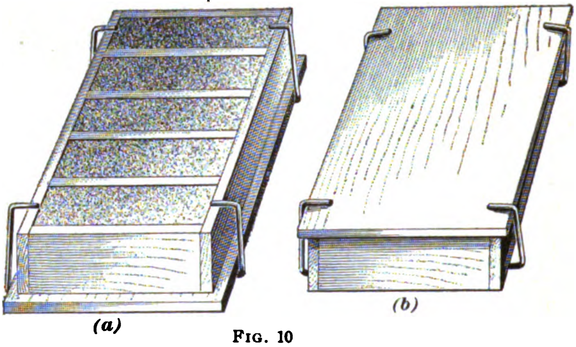

(*a*) (*b*)

FIG. 10

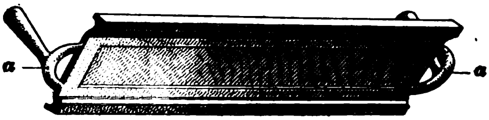


FIG. 11

When a mold is made in the manner just described, there will perhaps be very little finishing to do, but if the sand impressions need any smoothing or alterations, it should be done at this point. The gates or channels for the passage of molten metal are then formed by pulling out the plugs already mentioned. When the metal is poured into the box, it fills not only the space previously occupied by the pattern, but the gates or risers also. The casting will therefore appear as shown in Fig. 11. The gates *a*, *a* are knocked off with a blow from a hammer, after which the casting is cleaned.

13. In Fig. 12, the newel post is hollow and with ornament in low relief. Except in minor detail, the process of casting is the same as that just described. One-half of the pattern is laid on a board, as shown at *a*, and one-half of the molding box *c* is laid over the pattern and on the board *b*. Sand is rammed tightly all around and over the pattern, and the mold is then turned upside down. The board *b* is now removed, and the other half of the pattern is laid in place. The upper part of the molding box is then placed over the lower part and filled with sand around the upper half of the pattern, as before. The top part of the mold is now lifted off and the pattern withdrawn, leaving half of the mold, as shown in Fig. 13 (*b*); but, as the casting is to be hollow, a core will be necessary to form the cavity. This core

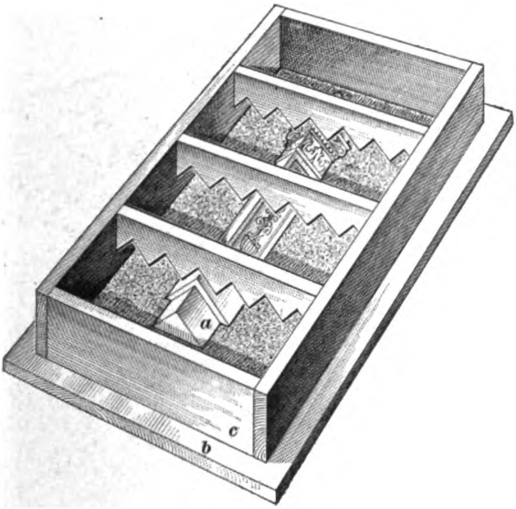


FIG. 12

consists of a block, or bar, of sand the size and shape of the hollow portion, or inside of the casting, as shown at *d*, Fig. 13 (*a*). The core is supported at each end in recesses *g*, Fig. 13 (*b*), formed for the purpose by projections on the pattern called *core prints*. When the core *d* is in place, resting on ends *e*, *e*, the recess *f* shows the thickness the metal will be when the newel is cast. The mold is now ready for casting, if gates have been provided and small holes, called vents, have been left through which the gases may escape. These gases might otherwise destroy the mold by causing an explosion when the molten metal is poured in. The core being adjusted and the gates formed, the box is closed and clamped as before.

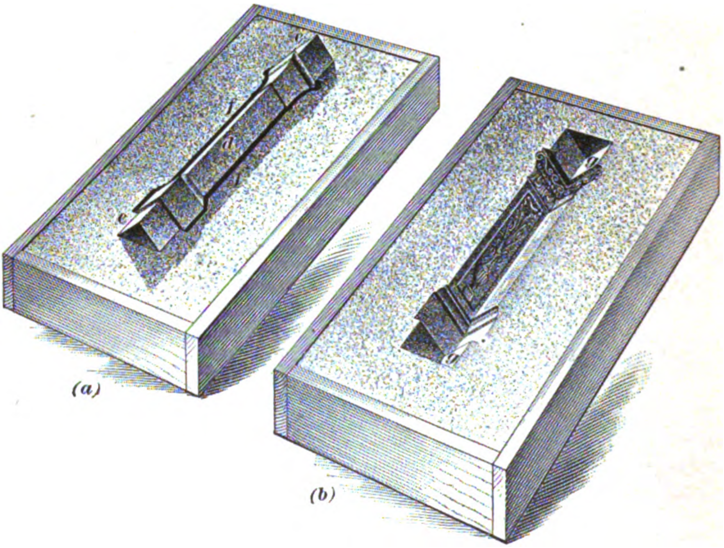


Fig. 13

This method of molding is the simplest and is perfectly suitable for any plain casting, but in a more elaborate piece of work, where the ornament is *undercut*, a different method must be resorted to, or the undercut portions, when withdrawn from the mold, will tear out a part of the sand with them. This method will be explained later.

14. Core Boxes.—The molds in which sand cores are made are called **core boxes**, and may be of wood, plaster, or iron, the space in the box corresponding in shape with the core to be molded. In some cases, the pattern is used also in making the core box. As an illustration, Fig. 14 (*a*) is one-half of a pattern from which hollow castings are to be made. It is shown lying on a board with core prints *e e* at each end. This pattern is embedded in plaster or a regular sand mold is made from it. Then a board and roller, Fig. 14 (*b*), are made, the edges of the board being raised equal to the desired thickness of the casting. Soft clay is laid on this board and rolled into strips, with which the sand or plaster mold is lined. Fig. 14 (*c*) shows the mold partly lined. This clay lining adapts itself exactly to the shape of the mold, and if an impression of the lining is taken, a model of the required core will be obtained. From this model can be made another plaster mold, which becomes one-half of the core box. It will look very much like the original mold

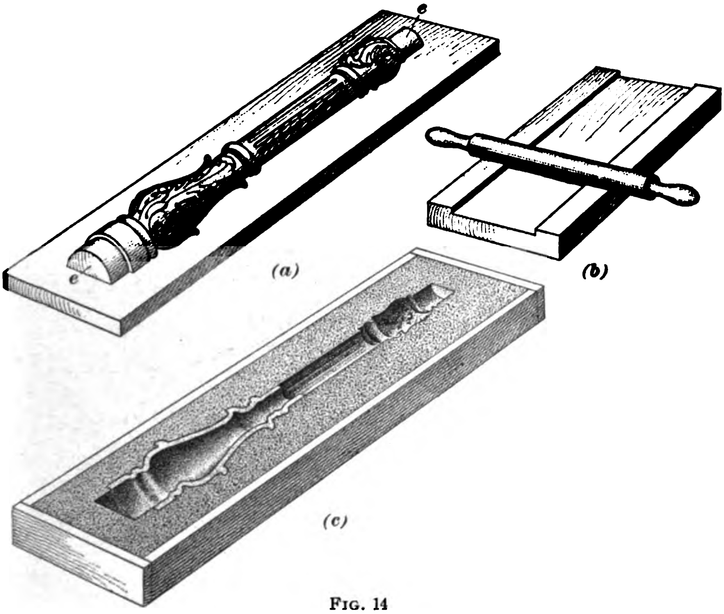


FIG. 14

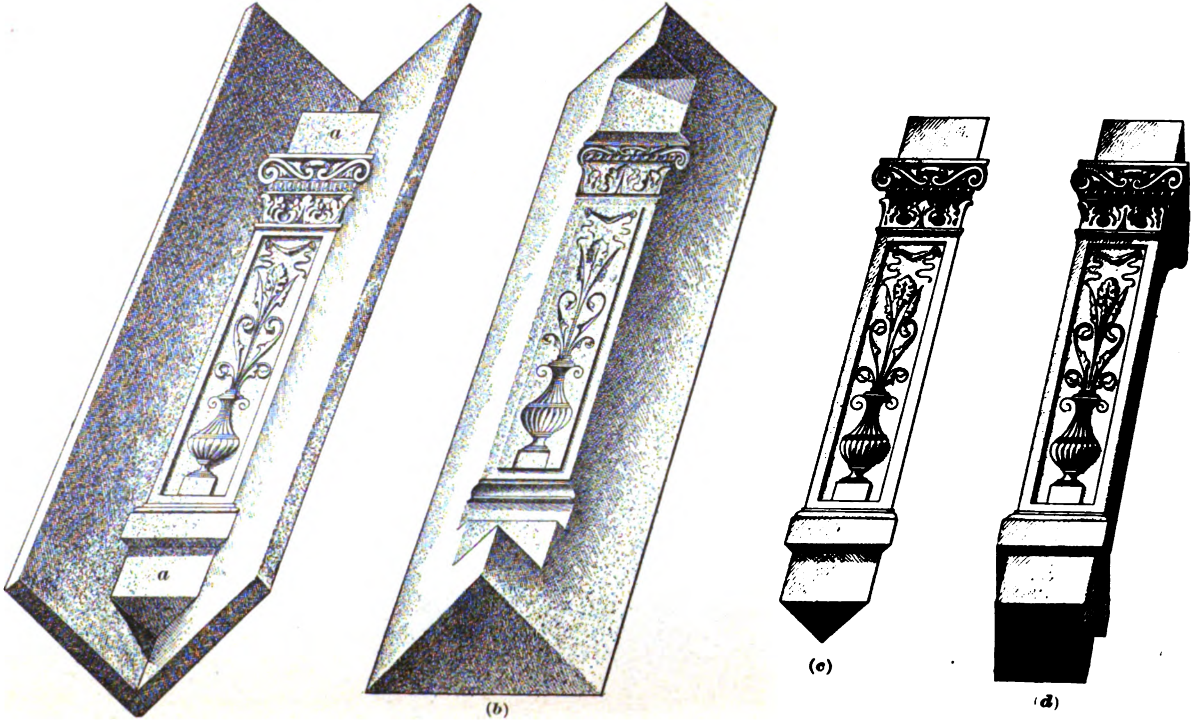


FIG. 15

taken from the pattern, without all the finer details of ornament, but the size of the cavity will be the thickness of the lining smaller, and this, of course, is what is desired.

15. Molding Four-Sided High-Relief Ornate Shapes. If the ornament is very bold, the pattern should be arranged in some other manner, otherwise it will not draw clear of the sand. There are various ways of obviating this difficulty, one being as follows:

Two boards somewhat longer than the required model are fastened together, as shown in Fig. 15 (*a*), forming a right angle, and in this is modeled one-quarter of the pattern with projections *a* at each end to form the core prints. When this model is complete, it is varnished and oiled. A plaster cast is then made by pouring plaster of Paris over the model and entirely filling up the angle between the boards, the result being a solid block with a reverse impression, as shown in Fig. 15 (*b*). This block when dry is used as a mold to produce the four quarters, Fig. 15 (*c*), needed to complete the original pattern. To make these four quarters, plaster is simply poured over the block (*b*), and roughly heaped up to form a ridge; then, by drawing a straightedge against each side of it in turn, the resulting casts are properly mitered, and may be fastened together with shellac, forming a complete model, as shown at (*d*).

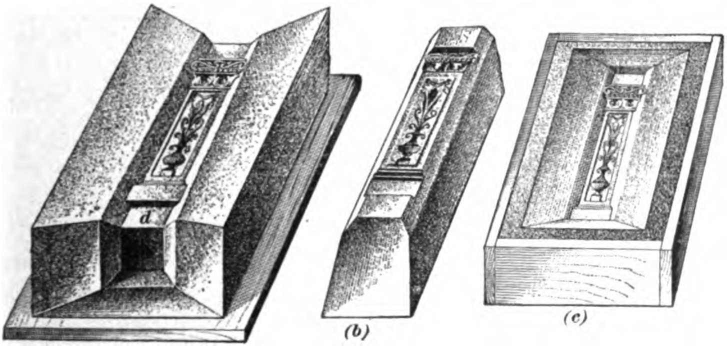


FIG. 16

The model is laid on a board and leveled up, as shown at *d*, Fig. 16 (*a*). The ornament at several points may rest on the board, but the body will be clear. It is then bedded up with clay, sloping the clay from the line of the lower edge of the model gradually down to the level of the board. Then the model is oiled to keep the wet plaster from sticking, and a plaster cast is made of both sides, sloping the plaster upwards to the top edge, and beveling the sides and ends as shown, the object of which will be seen later.

In Fig. 16 (*a*) the model is shown resting on a board, with the two plaster casts of the sides completed and lying against it. These casts, or molds, when detached, appear as shown in Fig. 16 (*b*). A plaster mold is made from each of these blocks. As these molds will be used in the foundry repeatedly, they should have a rough wooden frame to protect them from fracture, as shown in Fig. 17 (*a*).

Two blocks, as shown in Fig. 16 (*b*), are attached firmly with shellac to each side of the original pattern, thus bringing it back to the form shown in Fig. 16 (*a*). The pattern thus treated is ready to be put in the sand and consists of the main part, Fig. 16 (*a*), and the molds for the side parts, Fig. 17 (*a*). The original pieces, Fig. 15 (*a*) and (*b*), are kept only for the purpose of replacing the working patterns in case of accident.

This pattern *d*, Fig. 16 (*a*), is laid on its board and molded in the usual way. When the box is opened and the face of the pattern is brushed off, it will then appear as shown in Fig. 16 (*c*). The upper part of the box is then put in place and rammed up with sand, after which the box is opened and the pattern removed. The mold is left almost wholly in the lower box, as shown in Fig. 17 (*b*), and partly in the upper box, as shown in Fig. 17 (*c*). The plaster mold, Fig. 17 (*a*), is filled with sand, and so is the corresponding mold for the other side, thus making two blocks that correspond in shape and size with the recesses *m*, *m* left in the mold, Fig. 17 (*b*), into which they are carefully slipped. The core is put in place and the molding box is closed. The mold is now ready for the metal, it being understood that gates and outlets have been provided.

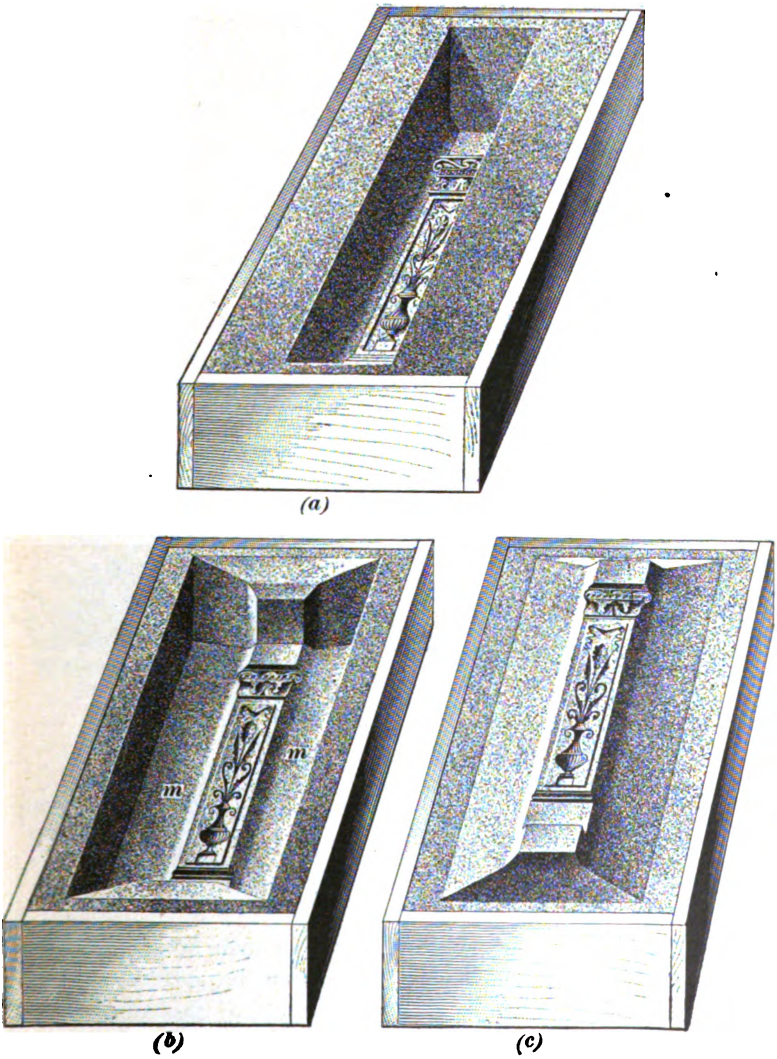


FIG. 17

16. The ornament in the example just given, although in such high relief as to preclude the pattern being made as mentioned in connection with Fig. 13, is not really undercut, as any one side could be drawn free from the sand. It is the combination of the four sides, together with the bold ornament, that necessitates the peculiar arrangement of the pattern. There are other means of reaching the same result, such as making the ornaments on two sides of the pattern detachable, so that after withdrawing the main part, or body, these loose pieces are left in the mold and can be picked out separately.

17. Undercut Work.—In undercut work, this latter method of making the ornament separate, to be picked out after the main part of the pattern has been drawn, is sometimes successful. The following will explain more fully what is meant by **undercut work** and how the patterns are adapted to meet the difficulty. Fig. 18 (*a*) shows a plain, flat square, or rectangular slab, with a vertical rib on the under side. It is evident that any such article may be molded in the ordinary way, as the entire pattern can be drawn straight upwards in the direction of the arrows, as at (*b*). Now, suppose that the rib is inclined at an angle, as shown at (*c*); the conditions are changed so that the pattern cannot be drawn in the same manner as in the previous case. The obvious solution of the difficulty is to make the pattern

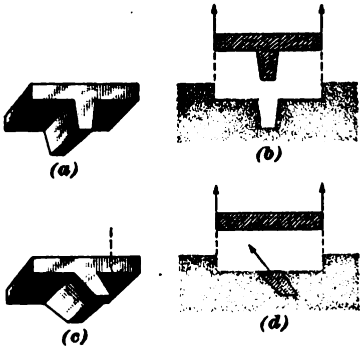


Fig. 18

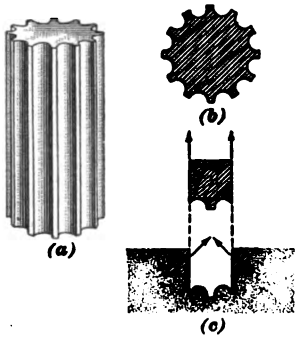


Fig. 19

in two pieces. Then, the upper section can be lifted vertically, leaving the rib to be drawn subsequently, as indicated by the single arrow in (*d*).

A somewhat different case is shown in Fig. 19 (*a*), being part of a fluted shaft, a section of which is also shown at (*b*). It will be seen that if this pattern were made in one solid piece, or even if the pattern were in halves, and had sand packed all around, being cast on its side, it would be impossible to get it free without breaking up the mold. The pattern should be divided into halves, and each half subdivided as shown at (*c*). Then, the middle section can be drawn straight upwards, and each of the side sections may be drawn inwards sufficiently far to clear the sand before being lifted out. In both of these cases, the result is gained by using loose pieces, or, in other words, by subdividing the patterns.

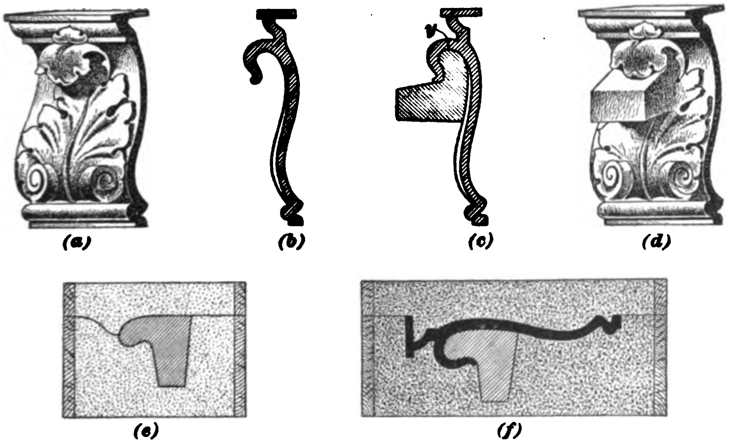


FIG. 20

18. Fig. 20 represents an example where other methods must be employed. The upper part of the foliage overhangs and forms a deep undercut hollow. At (*a*) is shown the original model, which is of clay, and (*b*) shows a section through the middle of the leaf. In order to get a working pattern, the model is laid flat on its back and plaster is poured into the hollow of the leaf so as to form into a square piece that will project outwards, as shown in section at (*c*) and in perspective at (*d*). This piece is called a *point.* At this stage, the whole model is turned over and plaster is poured over the back of it, forming a solid bed, or match. It is now required to separate the plaster point from the model. To do this, the top of the leaf at *y*, Fig. 20 (*c*), must be cut or broken away. Next, a plaster mold is made of this point, as at (*e*), and when this is done the point is replaced on the model and the top of the leaf is fixed in place again.

The model thus prepared and lying on its bed is covered with the molding box and the sand is "rammed home." The whole is then turned over, the block removed, and a sand mold made of the reverse side of the model. This half of the mold is lifted off, and the model is drawn (which can be done freely, since the hollow of the leaf is filled up by the plaster point). Meanwhile, a sand impression of the point has been made from its plaster mold, and this impression, or *core*, as it would be called, is dropped into its place in the space left for it by the plaster point in the sand mold, as at (*f*). The proper gates and vents being provided, the casting can now be poured. If the ornament should chance to be undercut at the lower part of the leaf also, additional points would be made in the same way.

19. In the process of casting, it is not good practice to have heavy pieces cast adjacent to much lighter ones. As the lighter parts cool very quickly compared with the heavy portions, the result would be disastrous, owing to the unequal shrinkage of the metal. Thin pieces shrink in a very short time, and in doing so are liable to crack away from the thicker parts, which retain the heat longer and consequently do not shrink so rapidly. These remarks should not be taken to mean that every casting must be of exact thickness throughout, but where there are variations of this kind adjoining, thick and thin sections should be graded together gradually, avoiding as much as possible any very abrupt change from one to the other.

A casting designed without regard to this matter may be molded successfully and in some cases the unequal shrinkage of the parts may be avoided by opening the box as soon as the molten iron has had time to solidify and thus exposing the thick portions to the atmosphere, while the thinner parts remain covered with the sand, in order that they may retain the heat for a longer period and thereby somewhat equalize matters. Even then there would be a certain amount of latent strain left, which would likely be sufficient to cause a subsequent fracture should the casting be subjected to a sudden jar or impact.

Having thus far described the use of iron as a medium for decoration and the processes generally used for cast-iron patternmaking, molding, and casting, the different structures and parts generally made of iron will now be considered.

STRUCTURAL DETAILS

20. Screws and Bolts.—In Fig. 21 (*a*) is shown what is termed a *square-head bolt.* Bolts of this kind are used for all common connections, such as the joining of two flanges or other surfaces that are not exposed to view. At (*b*) is shown a *screw-head bolt,* which is used for work where a countersunk head is necessary in order to obtain a smooth surface, the slot in the head being filled with putty after the work is in place. At (*c*) is shown a *countersunk-head bolt,* used for the same purpose as a screw head, and also for securing wooden stair treads to wrought-iron strings, so as to permit the head to finish flush with the tread. The countersunk-head bolt is also used in joining flat surfaces where a smooth finish is required.

At (*d*) is shown a *tap bolt.* This bolt is used for all connections where it would be impossible to get a nut on the end. The hole into which this bolt is to be screwed has a thread cut in it, or is "tapped," as the technical phrase would express it. At (*e*) is shown a *countersunk tap bolt,* which is used for joining very heavy work that requires a smooth-finished surface. After the bolt has been tightened up by the aid of a wrench, the square head is cut off.

Lagscrews, shown at (*f*), are used to fasten iron to stonework or woodwork; a plug of soft metal or wood is driven into a hole drilled in the stonework, and the screw is inserted into this plug.

At (*g*) is shown a *double-expansion bolt*, used for fastening work to brick or stone walls, and consists of a threaded bolt and an expansion shell into which the bolt screws. In using these bolts, the shell is first inserted into the hole made for it and the bolt is screwed into this. As the bolt *l* advances against the object to be fastened, the parts at *j*, *j* are pushed together, gradually spreading the shell and causing it to firmly grip the sides of the hole. The *single-expansion bolt* (*h*) acts in the same way, and is used for the same purpose. The chief advantage of these bolts is that they may be taken out without damaging the surrounding stonework or

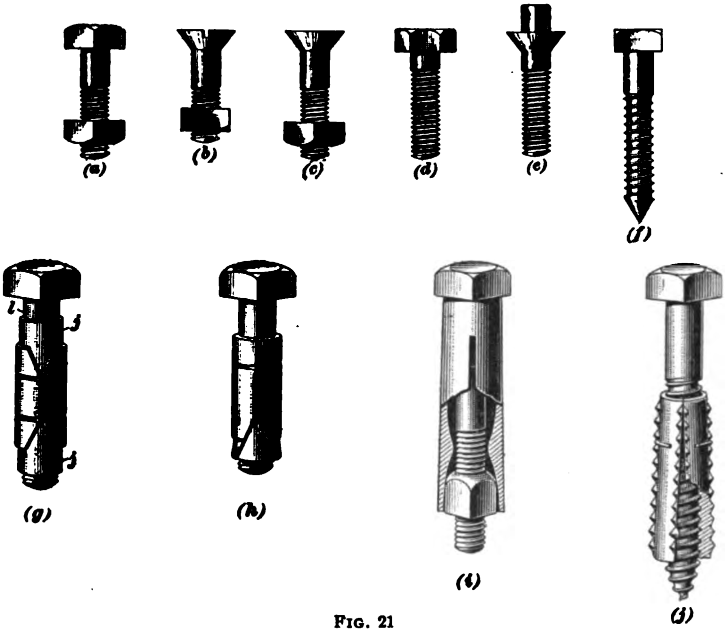


FIG. 21

brickwork. At (*i*) and (*j*) are shown two other types of expansion bolts; the shell on (*j*) is often made of lead, which accommodates itself very closely to the surface of the hole as the bolt is screwed up. Expansion bolts are also made with screw heads, for use where the surface will be exposed to view.

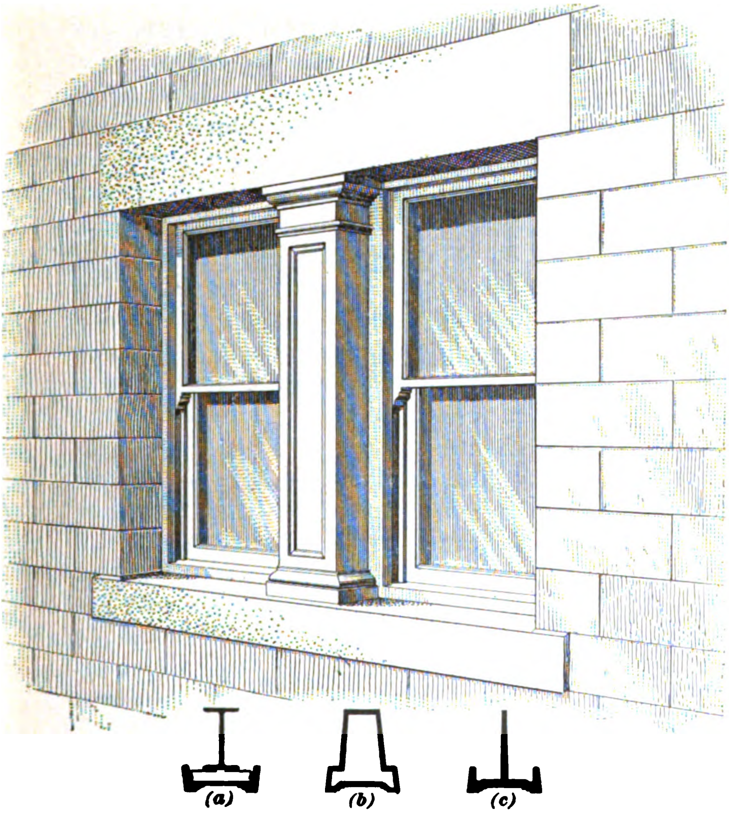


FIG. 22

21. Mullions.—A window such as shown in Fig. 22 is sometimes so wide that it requires a mullion, and the design of this mullion must be consistent with the rest of the building, no matter what its construction may be. In Fig. 22 is illustrated three ways of constructing such a mullion: (1) with an upright I beam and cast-iron facing, as shown in plan at (*a*); (2) with a cast-iron box on which the ornament is cast, as at (*b*); and (3) a modification of these two, which consists of a **T**-shaped casting with the ornament on the face, as at (*c*). The advantage of the first method is that the ornament may be applied without regard to the structural support, while in the other two, sufficient allowance must be made in the thickness of the metal to proportion the support to the load.

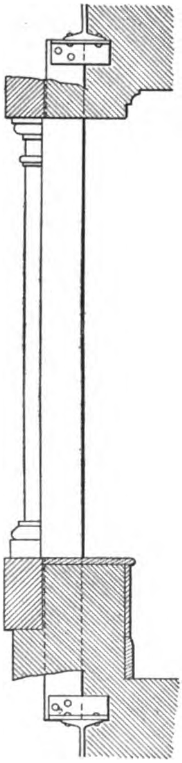


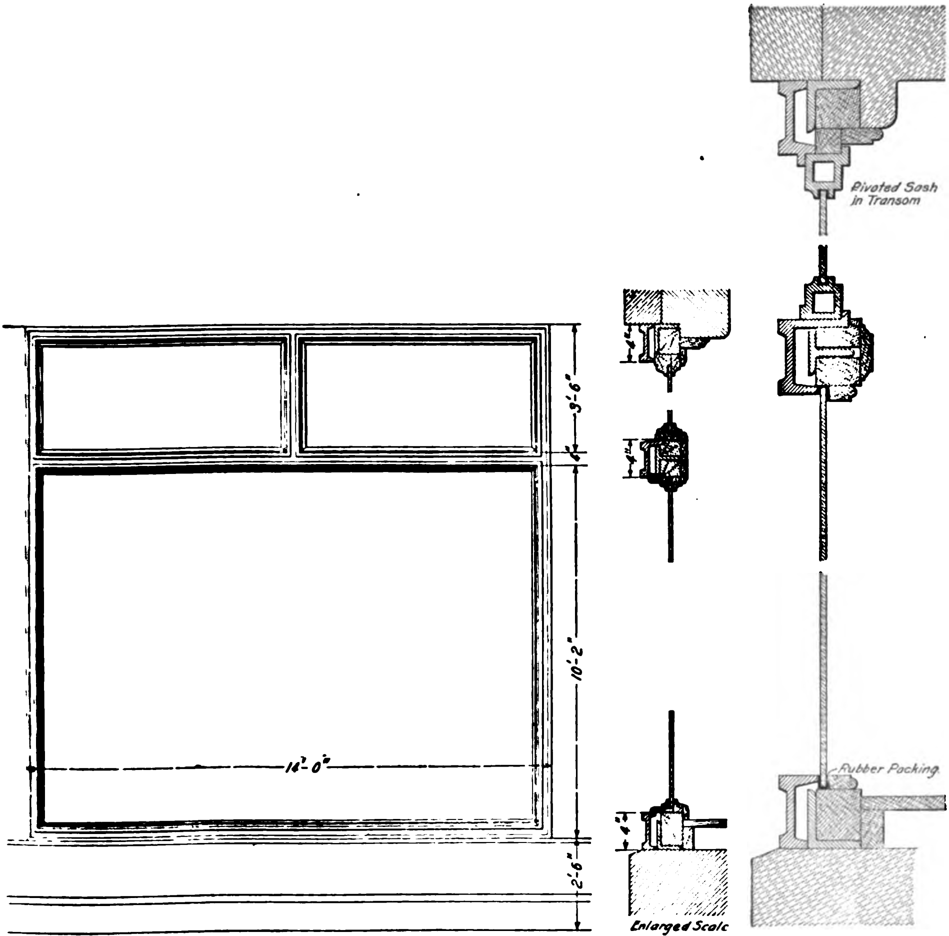
FIG. 23

In the first example (*a*), the cast-iron facing is screwed or bolted to the **I** beam. The decoration may be a simple panel, as shown, or a highly ornamented arabesque, according to the requirements of the design, for so long as the sides are plain, the casting of the mullion presents no particular difficulty, being only a plain panel, the pattern for which would be of wood about ½ inch thick with the sides slightly beveled or drafted to allow it to be drawn freely from the mold.

The length of the mullion is 8 feet; therefore, the pattern should be 8 feet and 1 inch in length, to allow for shrinkage.

If the design of the mullion is ornamental, the pattern may be entirely of plaster, or the body of wood and the ornament modeled in clay. If there are to be a number of these mullions in the façade, only one model is made; and, by covering this with plaster of Paris, a mold is obtained from which any number of wax duplicates can be cast of the original, which are then mounted on the body of the pattern for the mullion.

In the second case (*b*), the pattern should be made in a similar manner to (*a*), but, in addition, a core box is necessary, in which the sand core is made to be placed in the mold so that the desired thickness of metal is obtained. The sides of this mullion are checked or rabbeted to receive


3'-6"
6"
10'-2"
14'-0"
2'-6"
4"
4"
4"
Enlarged Scale
Riveted Sash in Transom
Rubber Packing

(a) (b) (c)

Fig. 24

the window frames, while in (*a*) and (*c*) the frame passes back of the reveal or side of the mullion.

The third case (*c*) should only be used where the superimposed load is small; its chief advantage lies in the fact that it does away with the use of the I beam without requiring a core for the casting, thereby saving both in the cost of manufacture and in the setting.

Mullions are sometimes set in between the sill and the lintel and fixed thereto, but in fireproof buildings with beam construction, a better plan is to run the back member, or web, of the mullion from beam to beam, so as to bind it securely to the framework of the building. Fig. 23 is a side view of a mullion fixed in this manner.

22. Window Frames.—Cast-iron window frames are sometimes designed as mere outer protection for the real wooden frames, as shown in Fig. 24 (*a*) and (*b*), where the ironwork is made after this fashion. This arrangement occurs mostly in show windows, and may be decorated as desired. The sash above the transom bar may be pivoted at the sides, so as to swing open for ventilation. Fig. 24 (*c*) is a vertical section of a similar window with no woodwork exposed to the action of the weather, the transom sash in this case being of metal. There is a structural frame of angles and tees with their ends built into the brickwork or fastened with expansion bolts, whichever is most expedient. To this frame the outer ironwork is screwed or bolted.

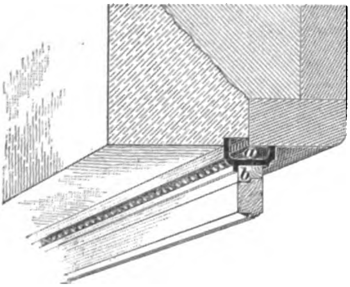


FIG. 25

This class of window is also framed as shown in Fig. 25, where the section of the window soffit shows a cast-iron frame, the outer edge of which takes the place of the weather stop and is ornamented with an egg-and-dart molding. The section of the iron jamb and head shown at *a* may be used for either a stationary window set directly in the iron frame or a French sash window, the hinges of which are secured to the iron frame with countersunk tap screws; or, when a wooden hanging stile is introduced, as shown at *b*, a pivoted sash may be used. The decoration of the weather stop and the inside of the frame should conform to the general design of the building.

The pattern for the body of the frame would be modeled in wood, and the decorated parts would be done in clay, cast in plaster, and applied to the body of the pattern. The outer and inner faces of the frame should have considerable draft, so that the casting may be easily withdrawn from the mold.

23. Although vertical sections are given in the preceding illustrations, they are by no means working drawings, and in order to show how this kind of work is prepared for the shop, examples are given in Figs. 26 and 27.

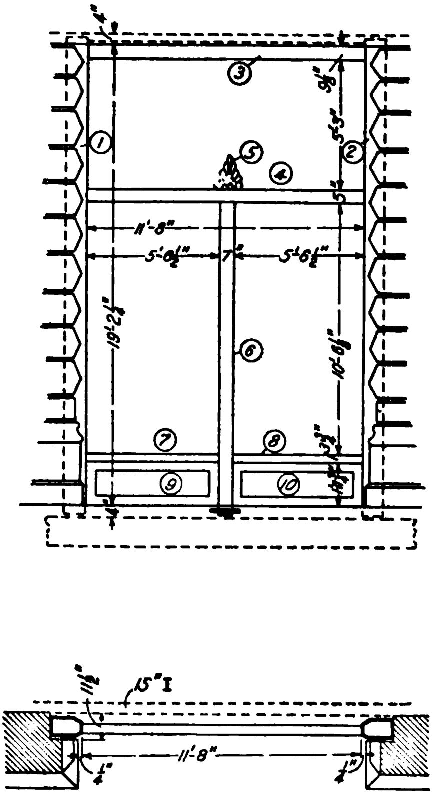


Fig. 26

Fig. 26 shows a block elevation and plan, or horizontal section, of an iron window frame, the sash of which is to be of wood. The various pieces are few in number and simple in design. Before commencing to lay out the working drawings of the ironwork, it is assumed that the stonework surrounding the opening is either already built or has been

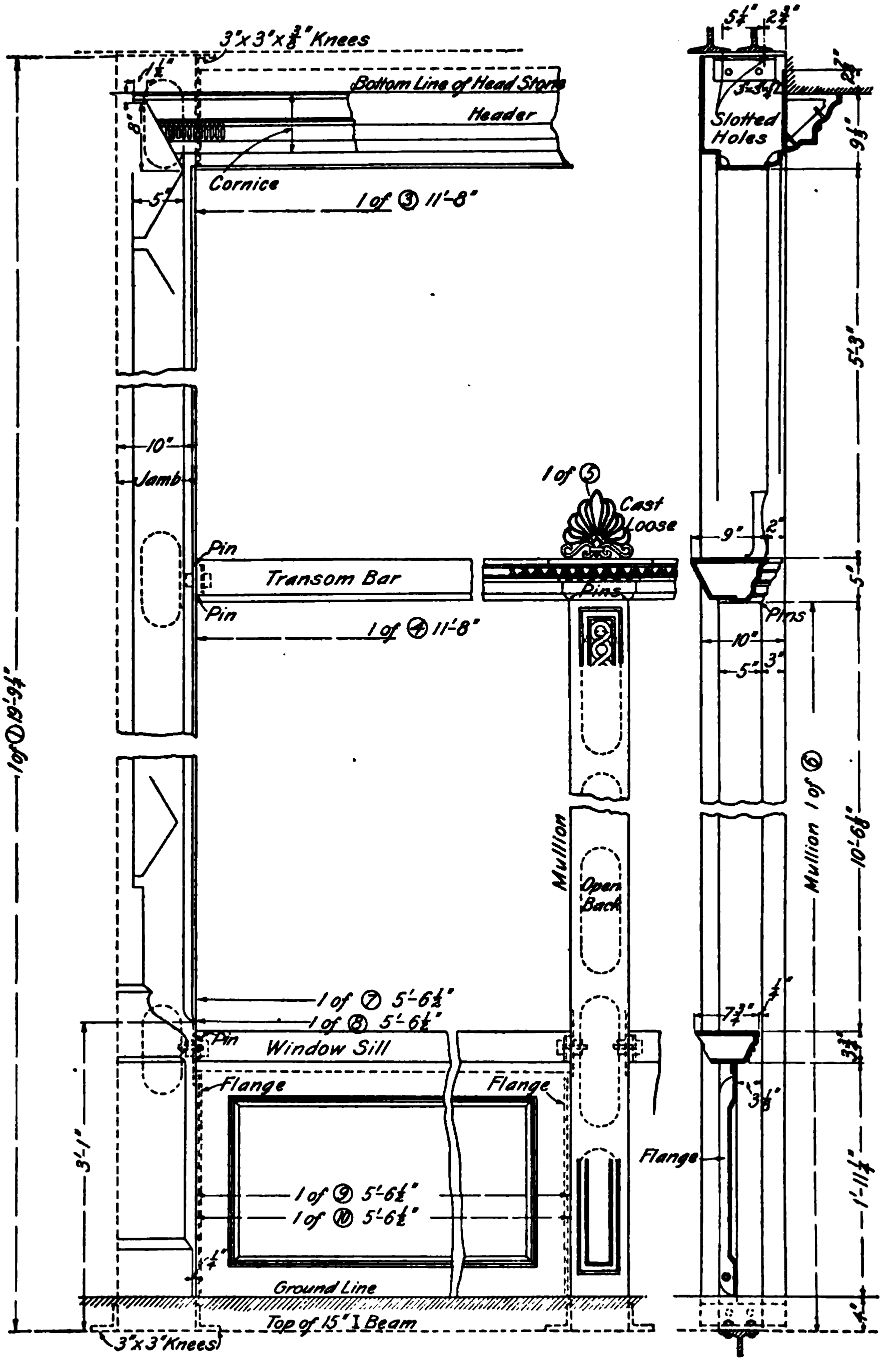

3"x3"x3/8" Knees
1 1/2"
Bottom Line of Head Stone
Header
8"
Cornice
5"
1 of ③ 11'-8"
10"
Jamb
Pin
Transom Bar
Pin
1 of ④ 11'-8"
1 of ⑤
Cast Loose
Pins
Mullion
Open Back
1 of ⑦ 5'-6 1/2"
1 of ⑧ 5'-6 1/2"
Pin
Window Sill
Flange
Flange
1 of ⑨ 5'-6 1/2"
1 of ⑩ 5'-6 1/2"
1/4"
3'-1"
Ground Line
Top of 15" I Beam
3"x3" Knees
1 of ① 18'-6 3/4"
5 1/4"
2 3/8"
3"x3 1/4 L
Slotted Holes
2 3/4"
9 1/8"
5'-3"
9"
2"
5"
Pins
10"
5"
3"
Mullion 1 of ⑥
10'-6 5/8"
7 3/4"
1/4"
3 3/4"
3 1/8"
Flange
1'-11 3/4"
4"

FIG. 27

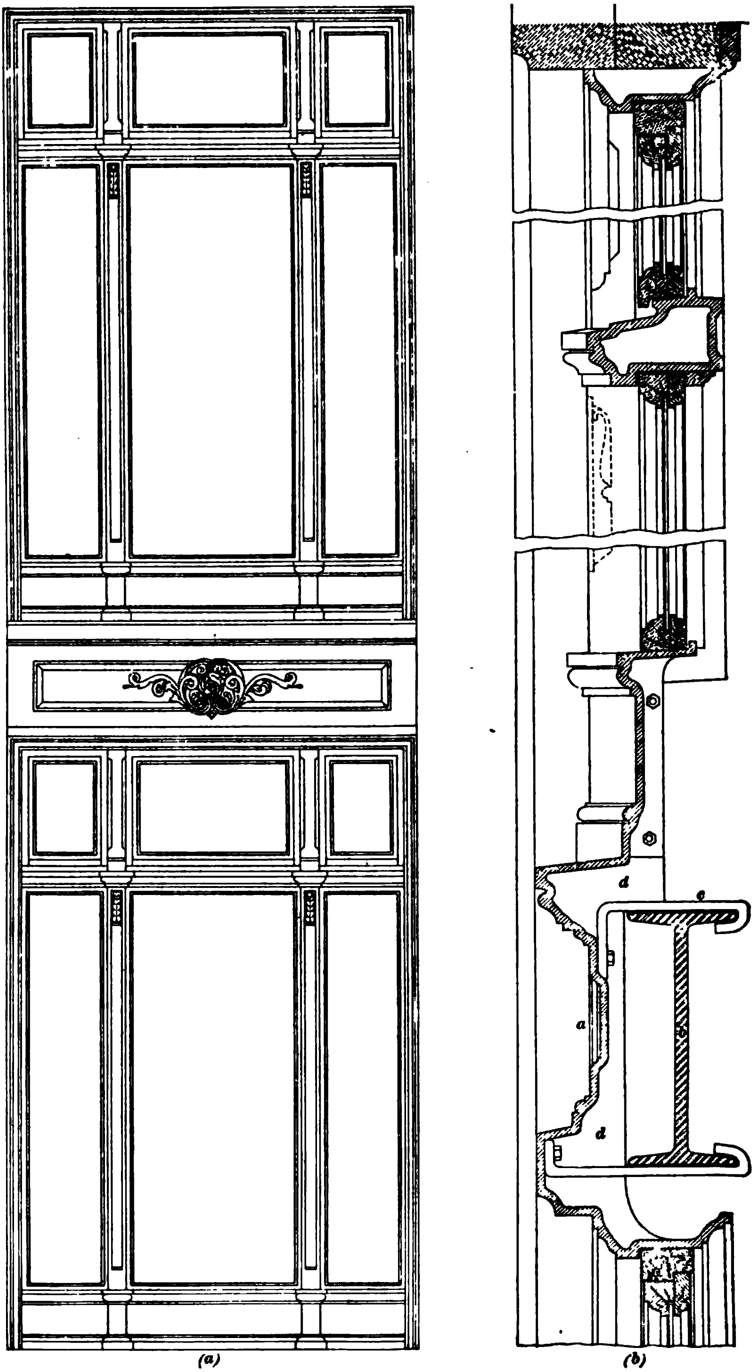
definitely decided on, so that the measurements may be obtained. These measurements being secured, the ironwork should be drawn full size for the information of the patternmaker. From the full-size drawings, it is an easy matter to draw the scale details necessary for the fitter and erector.

Usually, the molder does not need working drawings, as he gets his order for so many pieces to be cast from the pattern as they are handed to him. The fitter, on the other hand, should have scale details showing how the work is to be assembled, and the same applies to the erector, the full-size drawing being too unwieldy for general use. On the block elevation and plan, Fig. 26, are marked the general sizes and piece numbers of the parts, and on the larger detail, Fig. 27, is given fuller information, together with the quantity required of each casting with its corresponding piece number. The latter drawing also shows the construction of the whole, and should be supplemented by a written schedule, or list, of every piece entering into the composition of the completed work.

24. There is practically no limit to the use of iron as building material, and in many of the modern office buildings and hotels one of the principal features of the architecture is the long window bay running through half a dozen or more stories as shown in Fig. 28 (*a*). These may be constructed either entirely of iron or with iron frames and fascias, the sash being of wood or some light metal.

The section, Fig. 28 (*b*), shows the frame, transom bar, and fascia. Behind the fascia *a* is the floor construction with probably a beam, or girder *b*, to which the fascia is attached with hooks and bolts *c*, of whatever shape may be most expedient. Ribs *d*, *d* are cast at intervals on the back of the fascia, so as to bear against the top and edges of the beam. The hooks, or clamps, are made of the size and shape to suit the position they are to occupy.

The upper part of such a series of window bays surmounted by an imposing balcony is shown in Fig. 29. This



(a) (b)

FIG. 28

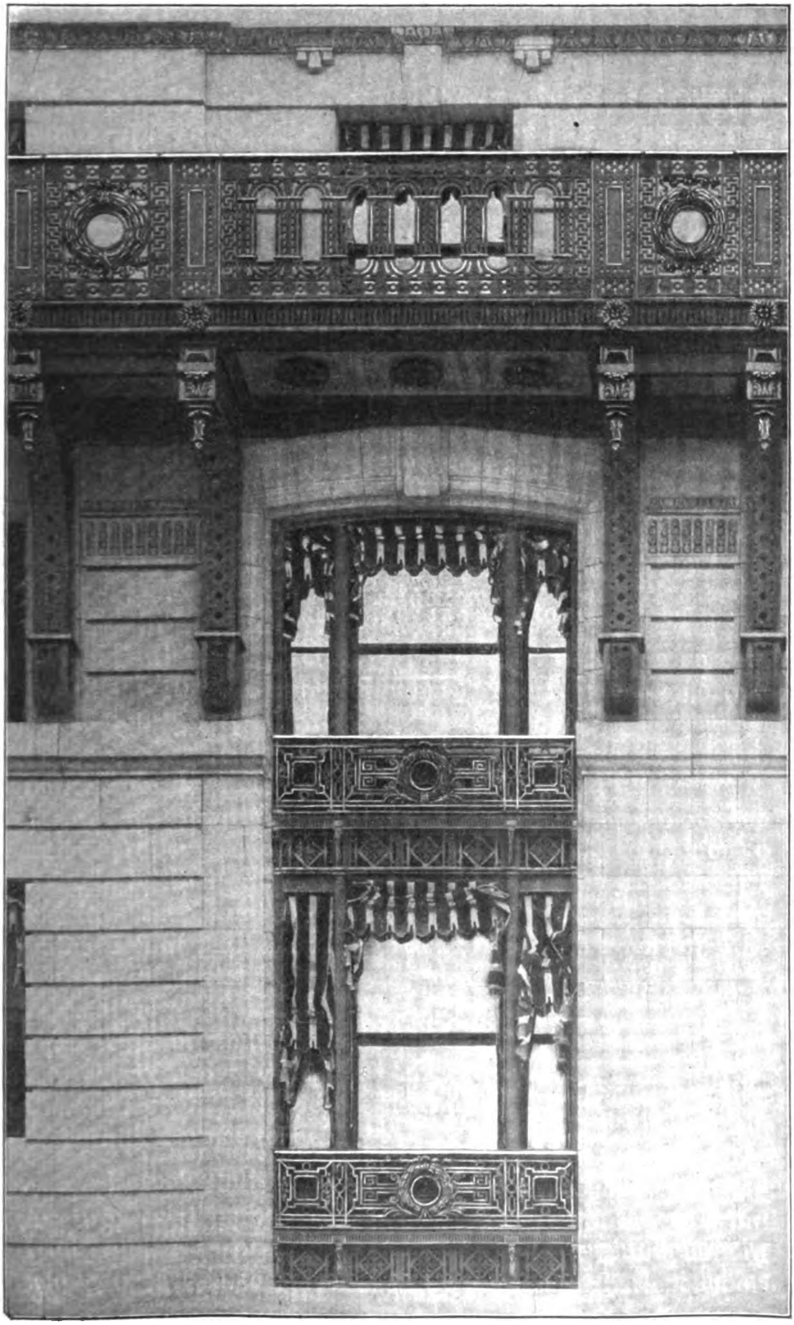


Fig. 29

particular design is an excellent example of the successful application of ironwork to building construction.

25. It frequently happens that the window-frame casting includes the outside casing and molded reveal, as in Fig. 30, which shows a richly ornate soffit. In this case, the reveal of the soffit *a*, or the jamb at the side of the opening, is first set, then the frame *b* is put in place, and last the casing, or architrave, *c*, the head of which is checked into the stonework. In the modeling and casting of these pieces the architrave *c* has the rosette ornament and reveal *b* has a repeating ornament both of which are molded and cast separately. By this procedure, only one model is required for the rosette and one for the repeating ornament, and castings from these are taken until the required quantity is obtained. Thus, in case of a failure in casting the ornament, the entire casting of the soffit or architrave is not made worthless, as it would be if the ornament were cast with the main detail in one piece and a portion of the ornament proved defective.

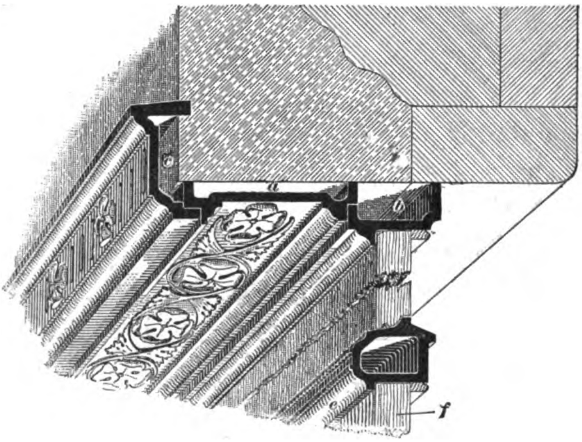


Fig. 30

26. Door Frames.—As a rule, when cast iron is used for a door frame, it is more properly a jamb and architrave, though in some cases the door frame itself is of iron, the same as a window frame, and the hinge butts are secured directly to it, unless a wooden frame has also been provided. The design shown in Fig. 31 is the soffit of a simple molded jamb and architrave, the wooden-door frame being fitted against it. Both the jamb and the architrave are secured to the stonework with expansion bolts, and the joints are bolted together with countersunk screw bolts. In designing a door frame, two chief points to bear in mind are the draft and the proper location of the joint between the two pieces. All joints of this character should be specially designed and so placed that they may form a practically invisible meeting line between two moldings, as shown at *a*. In very large work, and in buildings that are entirely of iron construction, it is better to set up, 2 feet apart, a series of 2″ × 2″ angle-iron jamb pieces to which the door jambs may be bolted; the inside ends of the latter have knees to which the door frame proper is bolted. The architrave should also have an angle-iron frame set up against the stonework and secured with expansion bolts, and the architrave should be fastened to this with countersunk screw bolts.

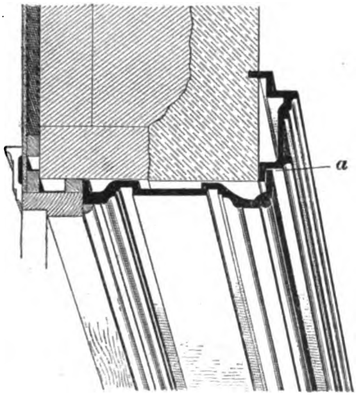


FIG. 31

27. Drawings for Window Frames.—The series of drawings shown in Fig. 32 illustrates a combined entrance and show window. With the exception of the full-size details, which cannot be reproduced here, this series forms a complete set of working, or shop, drawings. The general design of the ironwork is in harmony with the building of which it forms a part, and the details are worked out piece by piece in proper relation to each other and to the whole.

After the design is made, and before the work is detailed, it is necessary: (1) To measure the brick piers and the width of the whole opening between them; (2) to get the height from the first floor level to the under side of the girders overhead; (3) to note the exact position of the beams and girders at the ground level, together with their sizes; (4) to find the various levels of the sidewalk and the inside floor, and in fact to collect all information pertaining to the stonework, brickwork, and structural ironwork to which the ornamental work of the entrance and show windows is to be connected.

Having obtained all the data, and having the design already prepared, the working out of the details should proceed naturally. First comes the plan, Fig. 32 (*a*), which, like most plans in architectural drawings, is really a horizontal section; next, the plan, Fig. 32 (*b*), through the upper part of the show window; and then the front elevation, Fig. 32 (*c*), and the various sections (*d*), (*e*), (*f*), and (*g*).

The space left between the brick wall and the iron panel on the one side and between the adjoining building and the furring blocks on the other side is for pipes, otherwise the iron panel might have been set back close to the brickwork.

These drawings should be made in the order given, but as each one is so intimately allied to the other, it will be found that the details of construction will work themselves out as a whole. For instance, the facing of the piers and the plates and panels of the vestibule will be determined in relation to the height and width of their parts, as shown by the elevation and sections, so that as the drawings progress there will be a constant reference from one to the other. It should be borne in mind, however, that most of this work is drawn full size, and that scale details are merely smaller reproductions of the large drawings made in a convenient size for the use of the artisans in assembling, fitting, and erecting the work.

The reasons for putting up any structure are as varied as are the designs of the work. When it is remembered that there is practically no load to be supported and that the position of the joints are determined to a great extent by considerations of convenience, there can be no fixed rule in regard to this matter. To be successful, a knowledge of

molding is indispensable, in order to avoid bent and twisted castings. A careful examination of these drawings is better than any written explanation.

28. An excellent exercise is to make a complete schedule of this entrance and window, drawing each piece separately, both front view and section, and identifying it by its number (shown in the details enclosed in a circle). The result will be a very thorough understanding of the whole subject.

The pieces are numbered as follows: Cornice, *1*, *2*; frieze, *3*, *4*; dentils, on cornice, *5*; trim over window, *7*; trim around vestibule, *8*, *9*, *10*; trim at side of window, next pier, *11*, *12*; pilasters, *13*, *14*, *15*; ceiling, *16*; vestibule panels, *17*, *18*; consoles, *19*, *20*; soffit, *21*; mullions, *22*, *23*, *24*, *25*, *26*, *28*, *29*; sill, *27*; base panel, *30*; gutter, *32*; cornice, *33*, *34*, *35*; cartouch, *36*; base, *37*, *38*, *39*; various channels, angles, etc., *40*, *41*, *42*, *43*, *44*, *45*, *46*, *47*, *48*.

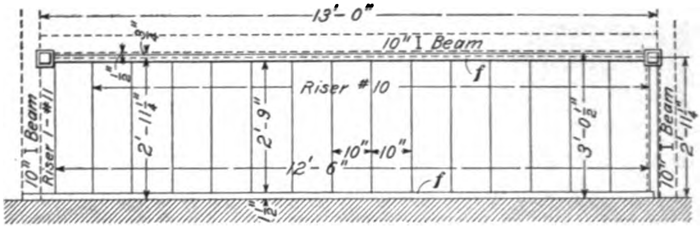
There are a few additional small pieces, such as angle knees and plates, which are attached to the larger parts, and belong to them. These are not distinguished by separate numbers.

STAIRS

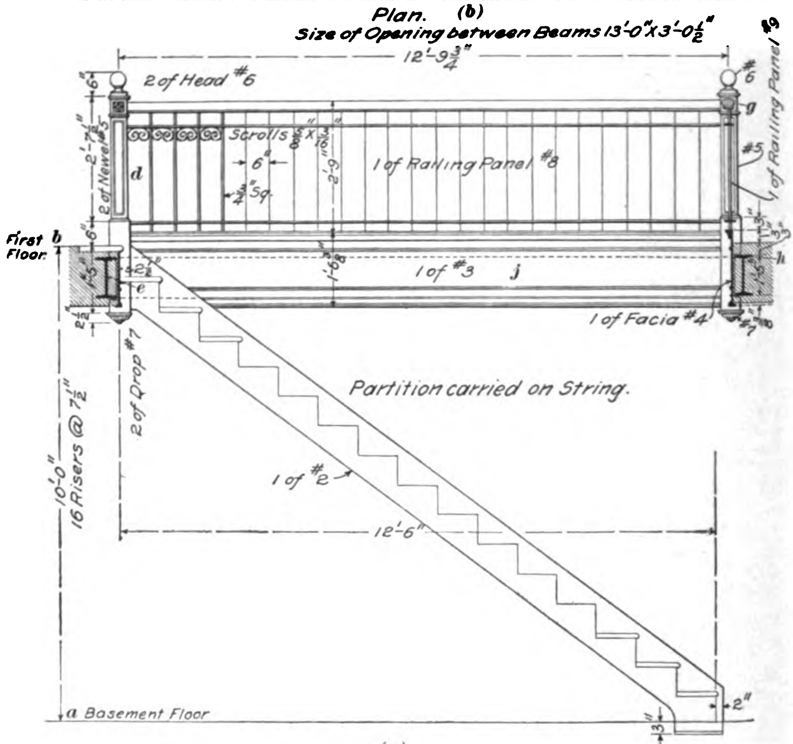
STRAIGHT-RUN STAIRS

29. **Stairways.**—The stairways in public buildings should be of iron, and by reason of the prominence of their location, it is usually necessary that their design should be in accordance with their surroundings. A number of stairways are herein shown, not to give a variety of examples, but to illustrate the different conditions that are likely to arise. Any of these designs may be stripped of its ornament and be used in the plainest structures, or the ornament may be increased and the design made suitable for a most elaborate interior.

The stairs shown in Fig. 33 are suitable for such use as a basement stairway or in a place where two floors are leased or used by one occupant and communication between them is necessarily independent of the public halls and stairs.



Plan. (b)
Size of Opening between Beams 13'-0" X 3'-0½"



(a)

FIG. 33

30. In laying out the drawings for the flight of stairs shown in Fig. 33, locate the center line of the newel *d*, 1 inch from the face of the beam *e*, and the face of the last riser at the center of the newel, and from this riser measure off 15 × 10 = 150 inches (there being fifteen treads), which will be 12 feet 6 inches and there locate the position of the face of the first riser. The framed opening of the well through which the stair is raised is more than the length of the stair, so that the headroom does not necessarily have to be considered. The width of the opening is 3 feet. The rise, the tread, and the position of the newel, the first and the last riser, and the width of the opening being fixed, a plan, as at (*b*), should be laid out, then the section (*a*), which shows the inside face of the string that finishes against the newel. The next point to consider is the finish of the well; this, as shown in the section (*a*), has a molded fascia *j*, a light hand rail of wood, a balustrade of wrought iron composed of ¾-inch square balusters with a top and a bottom rail, and two additional rails forming a frieze and dado through which the balusters pass, making a very stiff balustrade. The center line of newel *g* and the end rail are set 1¼ inches from the flange of the beam *h*. These points being fixed, the general layout is complete and the next procedure is to make the several parts in detail. It will be observed that the section (*a*) is drawn looking toward the railing.

31. The first piece to detail is the string *f*, the sectional shape of which is shown at *i*, Fig. 34 (*c*). The lug *k* is cast on the string, and supports the ends of the treads. The head of the outside string is cast with the base, or lower part, of the newel on it, and is shown in plan at *d*, Fig. 34 (*b*), and in elevation at (*a*). The plan (*b*) shows a lug *l* cast on the back of the newel that holds the string in place, and is secured to the flange of the beam with a hexagonal-headed bolt; the lug *m* is cast on the inside of the newel to receive the last riser.

On the right side going down, the string is bolted to the solid brick wall with expansion bolts, but on the bottom of the left-hand string there is a solid plate with braces, as at *u*, Fig. 34 (*c*). This plate carries the fire-block partition on that side of the stair. Instead of a partition there might be a piece of open grille-work between the top of string and the floor above, and in that case the string would have no bottom plate but would be molded or ornamented on the outer face. The object of having a solid partition is that

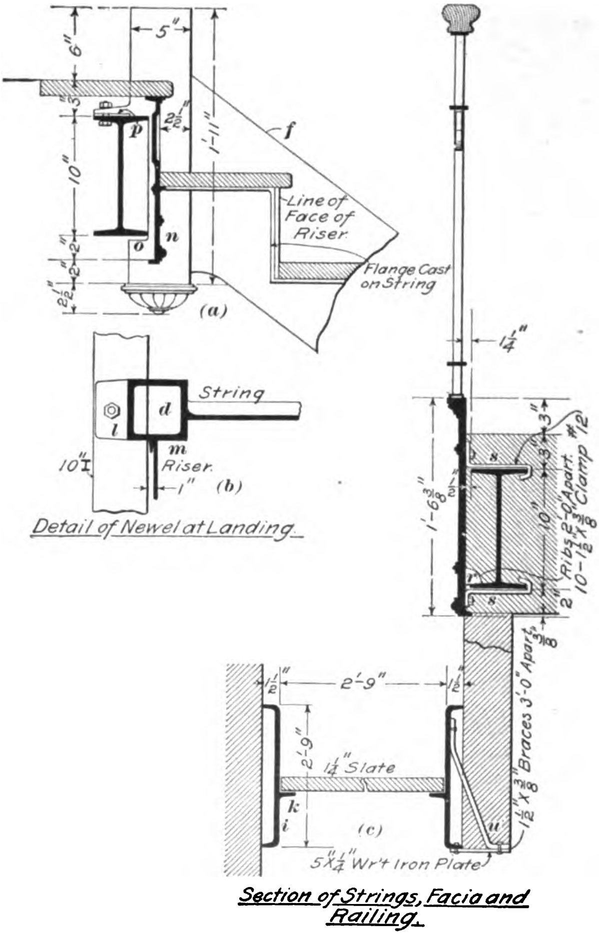


FIG. 34

the lower story may be shut off from the upper story, a door also being placed at the foot of the stairs for this purpose.

At *o* and *p*, Fig. 34 (*a*), a small allowance is made for any variation that might arise, thus enabling the erectors to raise or lower the stairs a fraction of an inch in case of necessity.

The angle newel is secured to the beam in the same manner as the newel *d*, and is cast with two lugs, so as to receive both the end and the side fascias. These fascias are cast with ribs *r*, Fig. 34 (*c*), along the back, 2 feet apart, in order to support them. The fascias are held in place by means of wrought-iron anchors *s*, *s*, to which they are bolted with hexagonal-headed bolts, which enable the erector to use a wrench in this close place.

The newels are cast with the upper part of each separate. A wrought-iron rod runs through the base and the shaft of the newel, the lower end passing through a plate in the base, and the upper end through a plate in the head of the shaft; the newel is thus held firmly together when the nut is screwed on. The caps of the newels are cast with a shoulder and are secured to the newel with countersunk screws. The lower rail of the balustrade is secured to the fascia with countersunk screws, and the upper rail in the same manner to the newel and wooden hand rail.

32. In Fig. 35 is shown one of the risers, which, except the top one, are all alike. The flange *v* in the section is cast on the lower edge and receives the marble or slate tread, and the nosing *w* is extended at the back to give a bearing for the tread. At *x* is a check in which the lug of the string fits. The upper riser of the flight differs from all the others, as it must be wide enough to form a fascia and finish under the stairs, as shown at *n* in Fig. 34 (*a*), and at the same time provide a stop for the plaster of the ceiling. The method of casting is not described, as it is perfectly plain work.

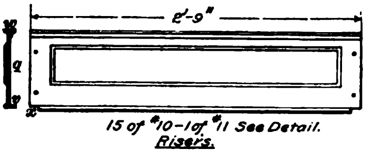
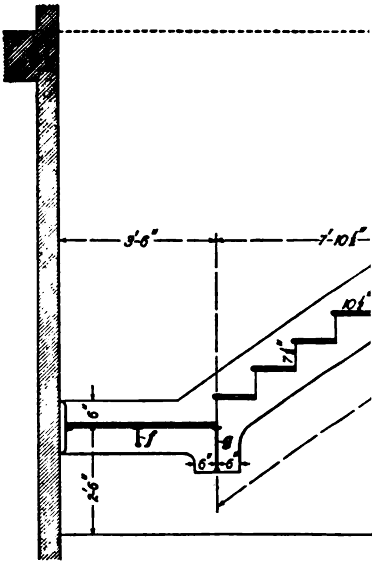


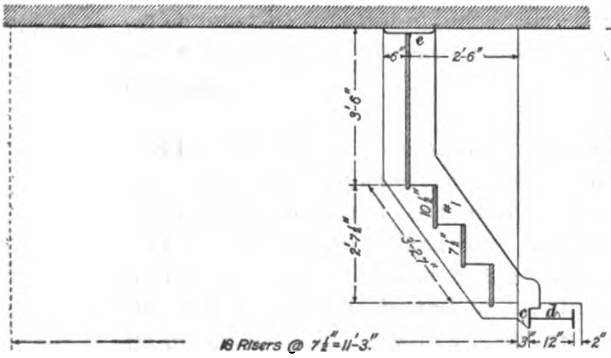
Fig. 35

PLATFORM STAIRS

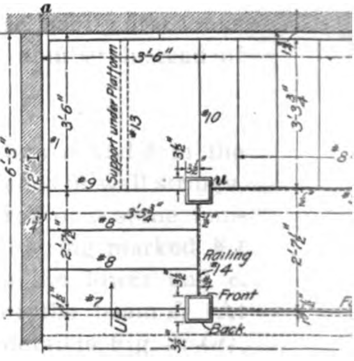
33. The stairs shown in Fig. 36 is one of a series of flights that may be used from the basement to the top floor of a building wherein the stairs just described would be suitable in the basement. This flight represents the run between the third and fourth floors of a building, and is typical of the whole stair system, which is enclosed on one side by a brick wall and on two sides with fire-block partitions. In many respects, the general construction is the same as in the previous example. The course to be pursued in laying out the stairs is the same as described for the previous case. The principal data to fix are: (1) the size of the well; (2) the height of the story; (3) the number of risers and treads, with their height and width; and (4) the width of the stairs. The drawing is then laid out precisely as in the preceding case, except that the parts in this example are numbered in the order they will be required, as is usually done with working drawings, in order to facilitate the process of erection. These numbers are marked on the plans, when laying out the stairs; and the workman, by referring to the plan, finds, for instance, that *# 1* indicates the wall string, which must be first put in place. He consequently first looks for *# 1*, and refers to each piece by its number instead of its name.

34. The holes indicated by the letters *a* and *b* in the plan, Fig. 36 (*a*), for the reception of the ends of wall strings, are 4 inches deep and contain either an iron or a stone templet for the strings to bear on. The wall string marked *# 1* in the elevation (*b*) has a lug cast on the lower end *c*, through which it is bolted to the top of the beam *d*. At its upper end a lug *e*, which is shown in detail in Fig. 37 (*d*), is cast to receive the end of the string *# 2*, which supports the platform and the stairs on the wall side of the second run. String *# 2*, shown in Fig. 36 (*c*), has two lugs at *f* and *g* cast on the lower end—at *f* to receive the light beam that carries the platform, and at *g* to receive the end of the

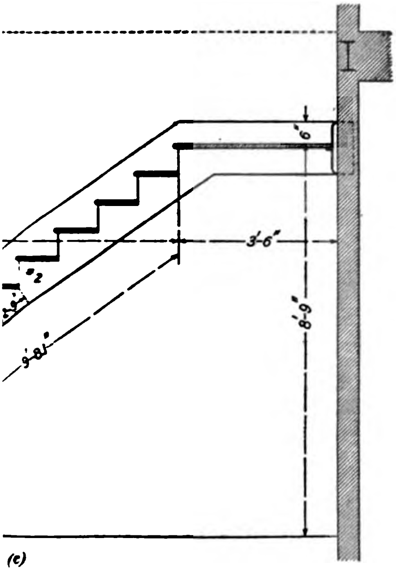

3'-6"
7'-10½"
10½"
7½"
6"
f
g
6"
6"
2'-6"


e
6"
2'-6"
3'-6"
2'-7½"
10½"
#1
7½"
3'-2½"
c
d
3"
12"
2"
18 Risers @ 7½"=11'-3."

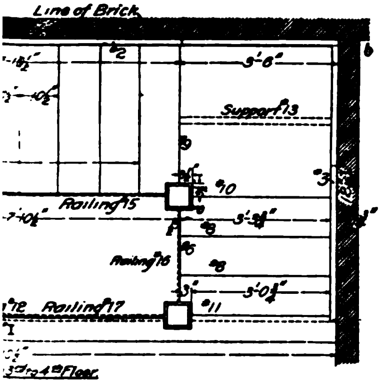
(b)


a
3'-6"
6'-3"
3'-6"
Support under Platform
#13
#10
3'-3¾"
12"
I
#9
3½"
u
3'-3¾"
#8
2'-7½"
#8
Railing
#14
3½"
Front
Back
#7
UP
3½"
2'-7½"
#8

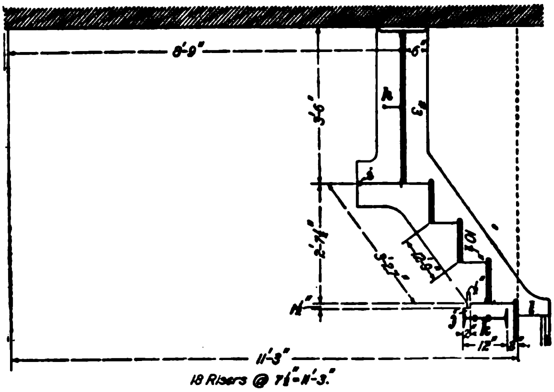
FI


6"
3'-6"
8'-9"
#2
9'-8½"

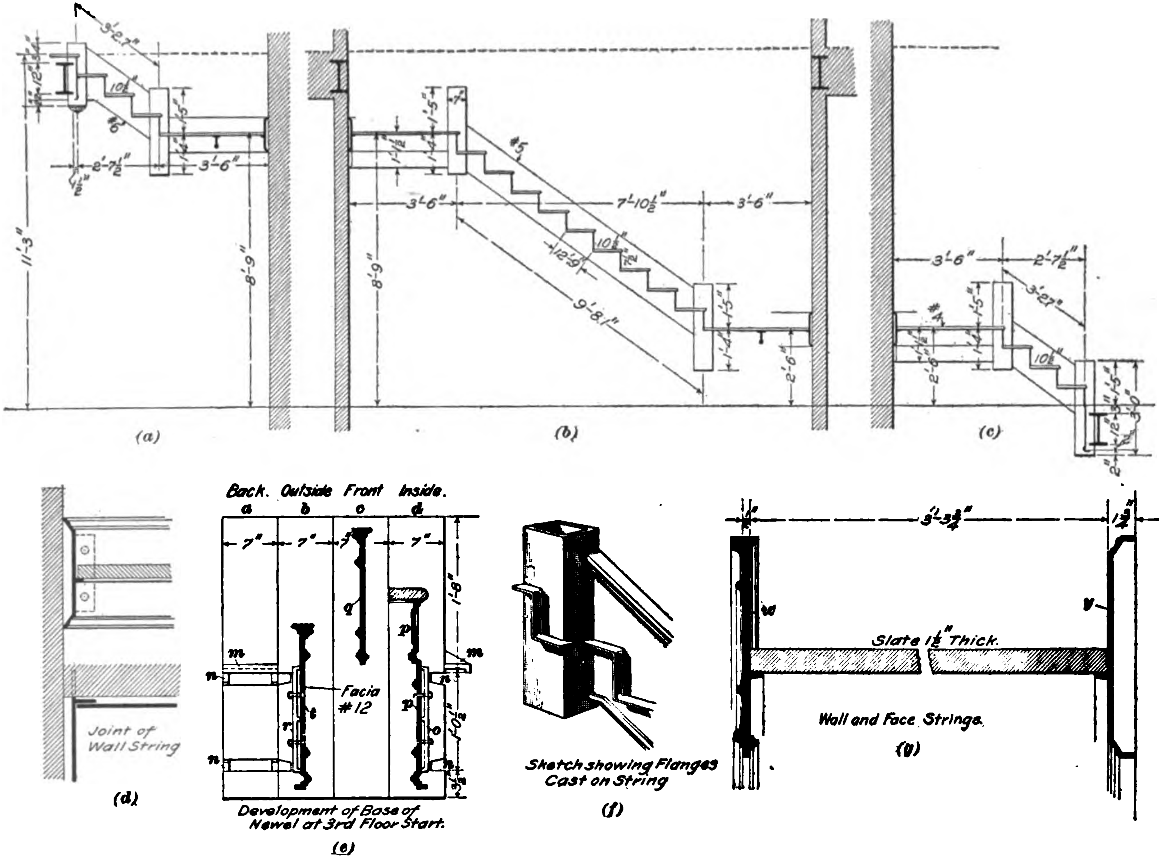
(c)


Line of Brick
#2
3'-6"
Support #13
#9
#10
#3
Railing #15
3'-3¾"
#8
#6
Railing #16
#8
3"
3'-0¾"
#12 Railing #17
#11
3rd to 4th Floor

(a)


8'-9"
6"
3'-6"
3"
2'-7½"
3'-2"
10"
11"
12"
11'-3"
18 Risers @ 7½" = 11'-3."

(d)



(a) (b) (c)

(d)

Development of Base of Newel at 3rd Floor Start.
(e)

Sketch showing Flanges Cast on String
(f)

Wall and Face Strings.
(g)

FIG. 37

face string marked *#4* on the plan. The upper end of string *#2* has a lug, the same as that on *#1* at *e*, cast on it to receive the wall string *#3*. String *#3*, as shown in Fig. 36 (*d*), also has on the lower part two lugs at *h* and *i*—at *h* to take a light beam to support the platform, and at *i* to receive the face string *#5*. On the upper part of *#3* is cast a flange at *j*, through which it is bolted to the beam *k*; there is also a small extension, or easement, *l* cast on this string to receive the base finish in the hallways. Provision for allowance or variation has been made at the floor ends of the strings *#1* and *#3*, as indicated.

35. The face string *#4*, as shown in Fig. 37 (*c*), is cast with the first two newel bases attached to it, the lower one of which has a lug cast on the back, as shown at *m*, Fig. 37 (*e*), which is a detail of the development of the base, through which it is bolted to the beam. This detail shows the base of the start newel developed flat so as to disclose all four sides. The back *a* is checked out at *n*, so that it may fit over the flange of the beam. The inside face of the newel *d*, against which the first riser must fit, has a lug *o*. The riser *p*, which also extends to form the fascia *p′*, is bolted with countersunk screw bolts to the lug *o*. The front face of the newel *c* shows the section of the face string *#4* at *q*, and the outside of the newel *b* has a lug *r* to which the well fascia *t* is bolted. The second newel base on string *#4* has a lug shown at *u*, Fig. 36 (*a*), cast on the outside to receive the end of the face string *#5*. The end of string *#4* is bolted to the lug *g* on wall string *#2* [see Fig. 36 (*c*)]. The face string *#5* has the third newel base cast with it, and extends through to the wall string *#3*, to which it is bolted. The lower end is bolted to the lug *u* on the second newel base. On the third newel is cast a lug *v*, to which face string *#6* is bolted at its lower end. Face string *#6* has the base of the fourth newel cast on it, and the lugs are practically the same as those shown in the detail.

The next pieces that demand attention are the risers. It will be noticed by referring to the plan, Fig. 36 (*a*), that there are five kinds of risers, and that each is indicated by a number commencing at seven and ending with eleven; these risers are the same as in the first example, and have been described, except those marked *# 9*, which have a lug cast on the back at the center to carry the outer end of the light beam *# 13*, which aids in the support of the platforms. The fascia *# 12*, a section of which is shown at *t* in Fig. 37 (*e*), has ribs cast 2 feet apart along the back to stiffen and support it, while clamps, which are bolted to the fascia with countersunk screw bolts, are hooked over the beam. A detail, Fig. 37 (*f*), shows a perspective view of the string and base of the newel, with the flanges to receive the treads and risers. In the detail shown in Fig. 37 (*g*), *w* and *y* are sections of the face and wall strings, showing the moldings of each, the position of the slate treads, and the flanges supporting them. The railings include *# 14*, *# 15*, *# 16*, and *# 17*, shown in Fig. 36 (*a*), and are the same as those shown in Figs. 33 and 34.

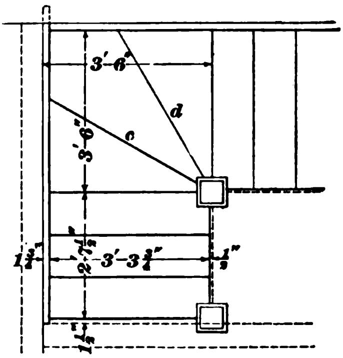


FIG. 38

It often happens that it is necessary to introduce winding treads in the angles instead of straight platforms. For example, had the distance between the partitions in Fig. 36 been but 11 feet 4½ inches instead of 14 feet 10½ inches, the treads might still have been kept 10½ inches in width by planning the corners as shown in Fig. 38. In this case, the strings would take a curve that would be determined by the

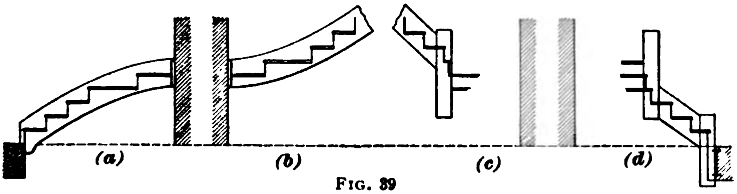


FIG. 39

intersection of the treads and risers with the wall string. The elevation of these curves is shown in the section in Fig. 39 (*a*) and (*b*). The only other detail affected by the difference of conditions would be the increased length of the newels brought about by the winder risers *c* and *d*, Fig. 38, having their start at the newel, thereby lengthening it by their height, as shown in the section in Fig. 39 (*c*) and (*d*).

SEMICIRCULAR STAIRS

36. In Fig. 40 (*a*) is shown the plan of a semicircular stairway; at (*b*), the development of the wall string; and at (*c*), the section through the strings; while in Fig. 41 (*a*) is shown the front elevation; at (*b*) the development of the face string; and at (*c*), a detail of the rail on the upper landing. The first three treads *a*, *b*, and *c* of the plan, Fig. 40 (*a*), are 11 inches wide, and the remaining ones are so spaced as to be wider than this, if measured on a line midway between the strings. The diameter of the well is 14 feet 6 inches; and, deducting twice the distance from the wall to the center of the treads, it will be found that the diameter of a circle drawn through the center of the flight is 9 feet 11⅛ inches, or 119 inches, which, multiplied by 3.1416, will give for the circumference 373.85 inches. Dividing this by 2 and deducting from the result 1 inch (the distance from the top riser to the beam *d*) gives the length of the center line required as 185.92 inches. This divided by the number of treads determines the width of each tread on that line to be 11⅝ inches. The lengths of the strings around the outer and inner circumferences are taken on the inside faces, and are determined in the same manner. In a stair of this character, it is not possible to make sections through any particular part in such a way as to be of any service, but the development of each string is given instead.

37. To lay out a plan of a flight of stairs of this kind, begin with the wall string and lay off from the foot of the flight the first three treads 11 inches wide, and the other

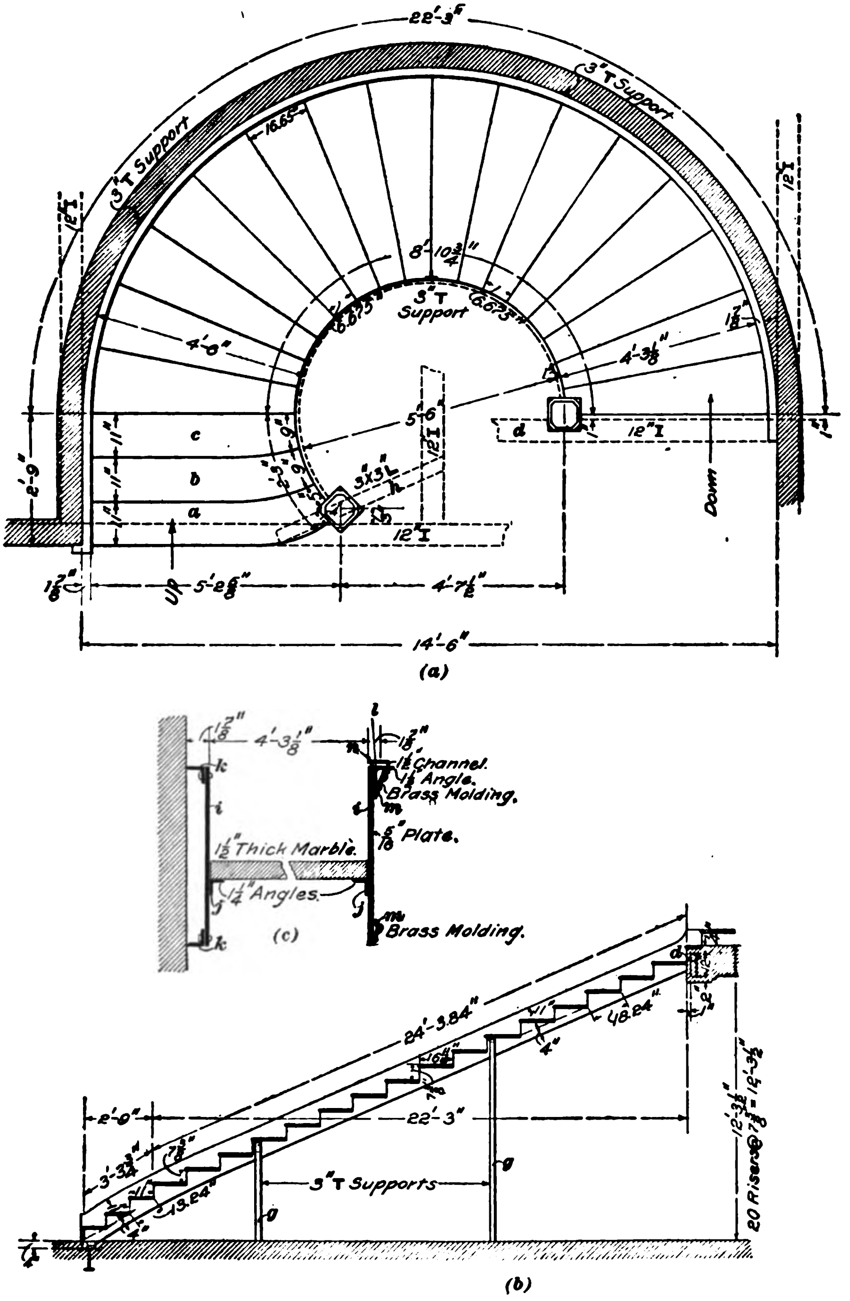

22'-3"
3"T Support
3"T Support
16.65"
12"I
12"I
8'-10 3/4"
3"T Support
6.673"
6.673"
1 7/8"
4'-6"
4'-3 1/8"
5'-6"
11"
11"
11"
c
b
a
d
12"I
12"I
12"I
2'-9"
3x3L
h
Down
Up
1 7/8"
5'-2 5/8"
4'-7 1/2"
14'-6"
1"
(a)
1 7/8"
4'-3 1/8"
1 7/8"
l
n
1 1/2" Channel.
1 1/2" Angle.
Brass Molding.
k
i
m
5/16" Plate.
1 1/2" Thick Marble.
1 1/4" Angles.
j
j
k
m
Brass Molding.
(c)
24'-3.84"
41"
48.24"
4"
16"
7"
d
12"
2'-9"
22'-3"
3'-3 3/4"
7 3/8"
13.24"
4"
3"T Supports
g
g
12'-3 1/2"
20 Risers @ 7 3/8" = 12'-3 1/2"
(b)

FIG. 40

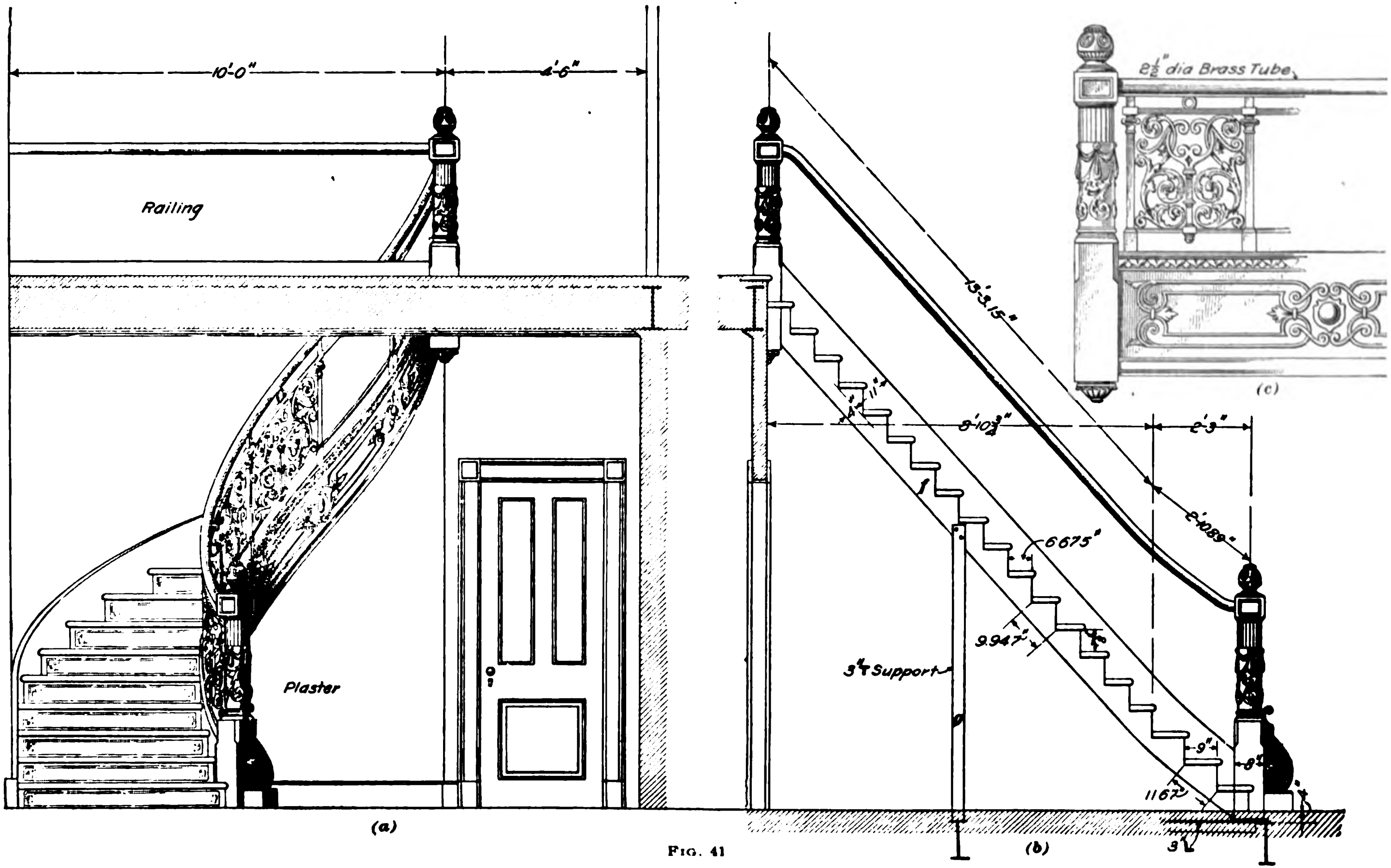

10'-0"
4'-6"
Railing
Plaster
(a)
13'-3.15"
8'-10¾"
2'-3"
2'-10.89"
11"
6.675"
9.947"
9"
8"
11.67"
3"
3¼" Support
(b)
2½" dia Brass Tube
(c)

Fig. 41

sixteen will be 1 foot $4\frac{11}{16}$ inches, the latter dimension being found in the same manner as the width on the center line and used in the development of the string, as shown at (*b*). A line drawn through the lower intersections of the treads and risers will form a basis from which to determine the width of the wall string and to lay off the top and bottom lines of this string, as shown in Fig. 40 (*b*). The proportion of the treads to the risers in the short straight part of the string is 11 to $7\frac{3}{8}$, while that of the curved portion is $16\frac{11}{16}$ to $7\frac{3}{8}$, thus causing the string to take a different angle; the juncture of these two parts should be eased off instead of showing the sharp angle, which would be out of harmony with circular stairs. This applies only to the wall string, as in the development of the face string, shown at *f* in Fig. 41 (*b*), there is a surface that is curved throughout its entire length. These curved strings are usually made of wrought-iron or steel plate that is capable of being bent to the required curve, and this bending is done by hammering on a curved block if the material is light, or by mechanical pressure in case of heavy work.

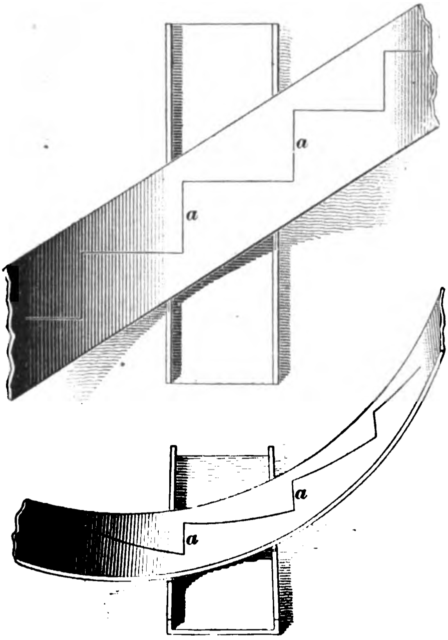


FIG. 42

38. With the exception of the straight part at the bottom of the wall string, both strings are helical in shape; that is, they take the form of a ribbon spirally wound around a cylinder and rising at a certain ratio.

To get this helical shape, the strings are first laid out flat, as shown in the developments, Figs. 40 (*b*) and 41 (*b*), with the lines of the treads and risers drawn on them; they are then laid across a block with the lines of the risers *a*, Fig. 42, parallel to the sides of the block, and while in this position are hammered or subjected to pressure every few inches. A wooden templet with one edge curved to the radius to which the string is to be bent is used to test the string and determine when it has been pressed to the proper curve. This templet is placed against the iron at short intervals, and held in a direction parallel to the lines of the treads. This bending may also be accomplished by passing the string in an angular direction through a set of rollers, provided they are long enough; this method, however, is seldom used, owing to the great length of roller required.

39. In making the pattern for the railing, it is advisable to first prepare a wooden drum of the same diameter as the stair well, on which the steps are laid out; and from them the top line of the string is obtained; which is also the bottom line of the railing. The top and any intermediate lines of the railing are then found by measuring perpendicularly from any point on the string line or from the center of each tread; and the whole railing may be either modeled directly to the proper curve or made straight and bent to the curve afterwards. The well holes of all stairs are framed before the stairs are built, and in straight stairs there is little more required in the shape of structural support; in curved stairs, however, it is often necessary to introduce special supports, as has been done in this case by the upright **T** irons *g* shown in Figs. 40 (*b*) and 41 (*b*). The circular partition under the string in this case is of terra-cotta blocks, and is therefore in itself incapable of affording sufficient support to the wall string. The strings should rest on the top of the floorbeams below, and should be bolted to the webs of the floorbeams above wherever possible; but, as this cannot always be done, diagonal bearings, such as shown at *h*, Fig. 40 (*a*), should be provided between the nearest beams.

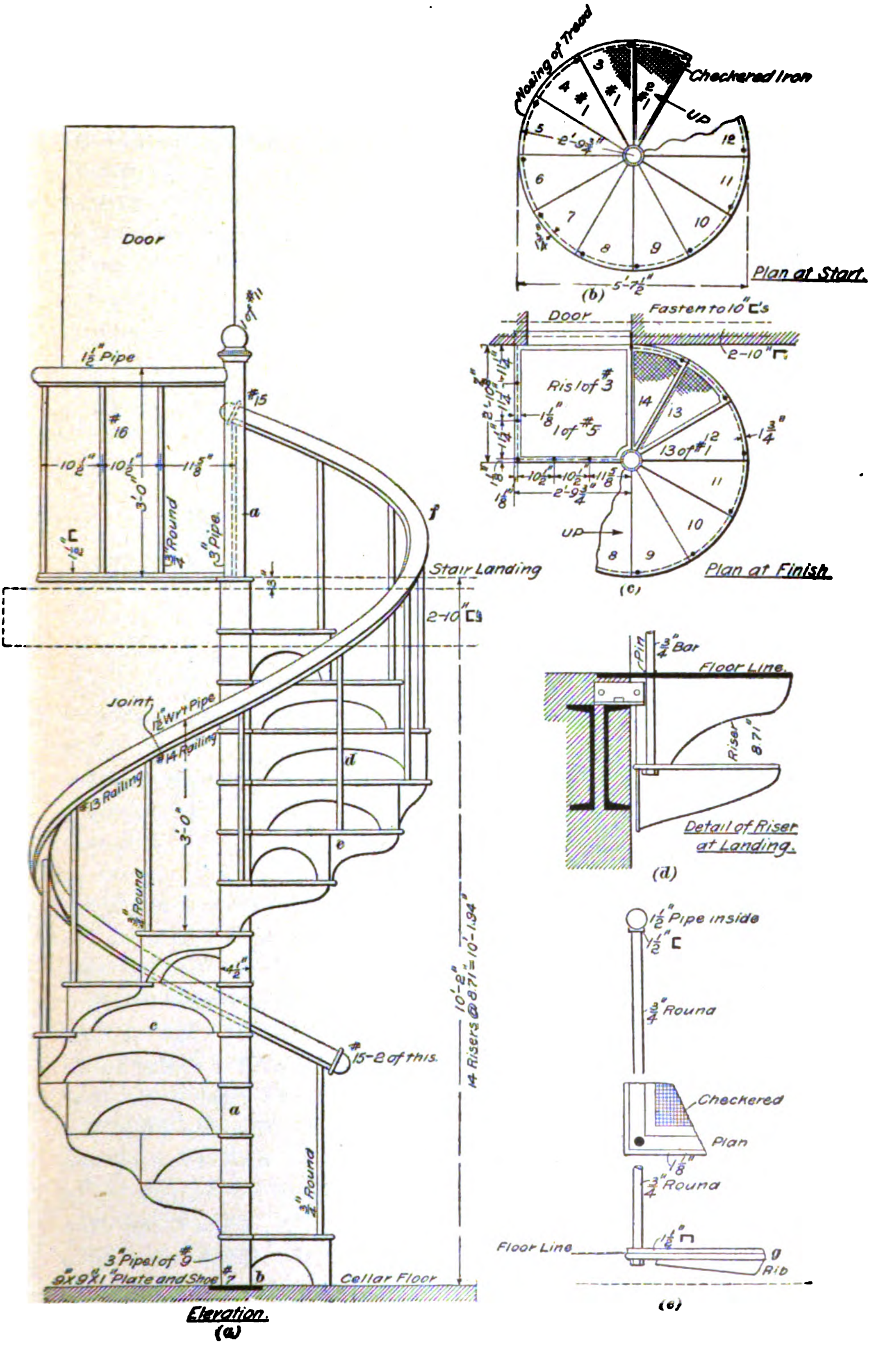
Nosing of Tread
Checkered Iron
3
4 #1
#1
2 #1
UP
5
2'-9¾"
12
6
11
7
10
8
9
5'-7½"
(b)
Plan at Start.
Door
Fasten to 10" ⊏'s
2-10" ⊏
Ris 1 of #3
1⅛" 1 of #5
14
13
12
13 of #1
1¾"
11
10
UP
8
9
10½"
10½"
11⅝"
2'-9¾"
2'-10⅞"
(c)
Plan at Finish.
Door
1½" Pipe
1 of #11
#15
#16
10½"
10½"
11⅝"
3'-0"
¾" Round
3" Pipe
1½" ⊏
a
f
Stair Landing
4½"
2-10" ⊏
Joint
1½" Wr't Pipe
#14 Railing
#13 Railing
d
3'-0"
¾" Round
e
4½"
c
#15-2 of this.
10'-2" 14 Risers @ 8.71" = 10'-1.94"
a
¾" Round
3" Pipe 1 of #9
9"x9"x1" Plate and Shoe #7
b
Cellar Floor
Elevation.
(a)
Pin
4½" Bar
Floor Line.
Riser 8.71"
Detail of Riser at Landing.
(d)
1½" Pipe inside
1½" ⊏
¾" Round
Checkered
Plan
1⅛"
¾" Round
Floor Line
1½" ⊓
g
Rib
(e)

FIG. 43

40. The face string being of wrought iron, it must be bolted to the newel faces, and in view of this, flanges are cast on the newel bases for this purpose. The constructive details for these stairs in the connections, with the exception of the strings, are the same as in Fig. 36. These strings are shown at *i*, Fig. 40 (*c*); the treads are supported on wrought-iron angles *j* bolted to the string. The top and botton angles *k k* of the wall string and the top angle *l* of the face string are of angle irons riveted to the string. The upper and lower edges of the face string are finished with brass molding *m*, and the balustrade is first secured to the channel iron *n*, which in turn is bolted to the string.

CIRCULAR STAIRS

41. A type of circular stairway, similar to that described in *Architectural Drawing*, is shown in Fig. 43. This stairway is suitable in some such position as an engine room, from a sidewalk to a subcellar, or from an attic to a dome, or tower, or in any position where space is limited. The construction is of the simplest character, and consists of a central core or wrought-iron pipe *a* resting on a plate *b* at the bottom. The treads and risers *c* are of cast iron in one piece, with a collar to fit over the pipe *a*, so that in erecting the stair the risers and treads are slipped on as shown in Fig. 44. In order to keep them in place, the upright bars of the railing *d*, Fig. 43 (*a*), are continued down through each tread near the front edge to a lug, or projection, *e* on the back of the tread immediately

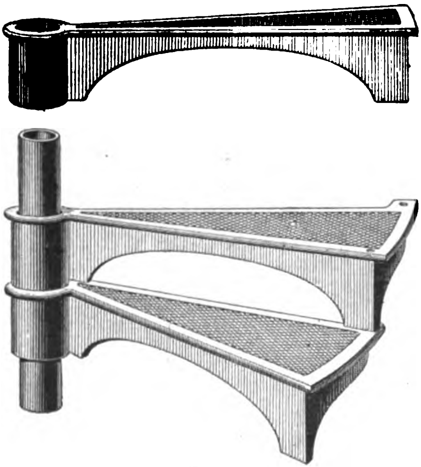


FIG. 44

underneath, and are secured with a nut. The top riser acts as a brace to hold the pipe in place, and is fastened to the beam with a wrought-iron strap of any suitable shape. There are no strings to be bent in these stairs, but the hand rail *f* must be bent to the proper curve. This rail is composed of a small channel iron with a 1½-inch wrought-iron pipe on top.

42. To bend any bar or pipe, the most satisfactory results are obtained by using rollers, preferably run by power, as shown in Fig. 45, one of these rollers being capable of adjustment, so that the pipe or bar may be bent to any required radius. In this way, not only is it possible to give the hand rail the necessary curve, but, as the amount of rise per foot is known, it can be given this upward direction at the same time by setting the gauges, or guides, *a* and *b* to the proper angle. It is presumed that the stair is erected before the hand rail is bent; and to determine if the rail has been bent to the proper curve, it is laid over the top of the steps, and corrected by hand if necessary.

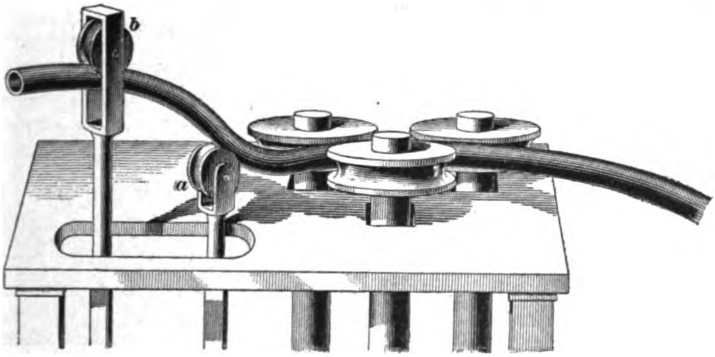


Fig. 45

It might, however, be required that the hand rail should be bent and set quite independently, and assuming that the rail were a flat bar, 1½ in. × ⅜ in., it would be accomplished as follows: An end view of a tread and riser would be laid out in outline, the sizes being taken at the center line of the railing, as shown in Fig. 46 at *b*. A part plan of the stairs, showing two treads, would then be drawn, as *ea* and *af*, with a dotted line *cd* through the points *e*, *f* where the tread lines intersect the outline of the stair plan. Then, from *a* as a center, and with a radius equal to *b* (the true length of the rail over each step), arcs would be struck, intersecting the line *cd* at points *g* and *h*, which points are located on the true curve of the rail. A circle described through the points *g*, *a*, *h* would give the curve to which the hand rail should be bent. The bar is then bent to this new radius and twisted evenly along the whole length of the stairs in the manner and with the tools shown in Fig. 47. It will be found that the whole bar has now the form of a helix, and is of the required radius. Before being twisted, the positions of the balusters should be marked on the bar, and the holes for them bored or punched, as the case may be.

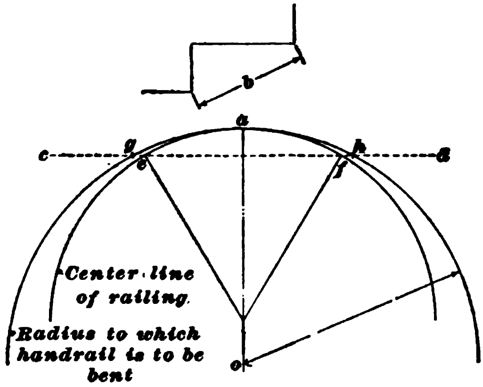


FIG. 46

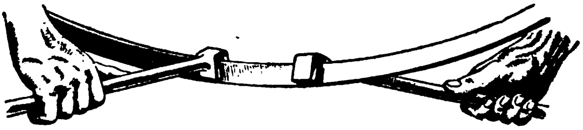


FIG. 47

43. In Fig. 43 (*b*) and (*c*), are two plans, one showing the start at the cellar-floor level and the other the finish of the stairs at the platform. The detail of the connection at the platform, the method of securing the baluster through the tread, and details showing the corner of the platform and the pipe forming the rail are shown at (*d*) and (*e*). The platform is strengthened by the ribs *g* cast on the under side, as shown at (*e*).

FRIEZES AND BALUSTRADES

44. Friezes.—In Fig. 48 is shown a cast-iron frieze. The ornament is bold, and has considerable relief, but being entirely on the surface and not undercut, it does not present any special difficulty in molding, and the model may be withdrawn from the sand without injuring the ornament. The modeling of this frieze should be in clay and then cast in plaster, and the working mold should be cast from this plaster model in the same material.

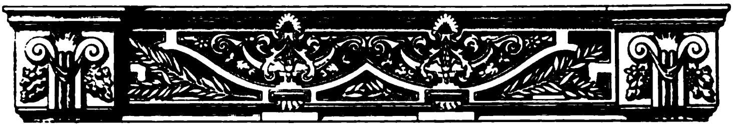


FIG. 48

45. Balustrades.—Figs. 49 and 50 are examples of stair balustrades or panels. Figs. 51 and 52 are examples suitable for exterior or exposed positions. The newel *a*, Fig. 49, is modeled, molded, cored, and cast in the same manner as the one already described. The balusters *b* are carved in wood and cast *solid*. They are secured with countersunk tap bolts at the bottom and top to an iron strap or rail *c* and *d* $\frac{1}{4}$ inch thick, and of a width equal to the baluster base, or to a channel iron.

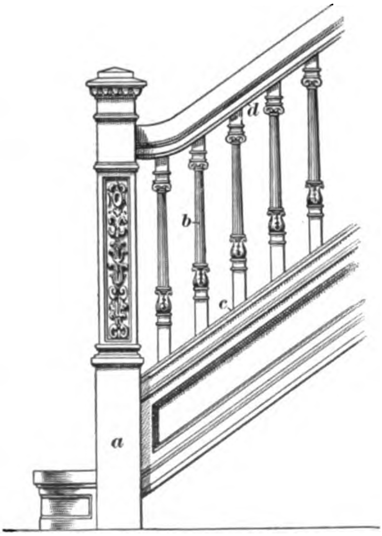


FIG. 49

The characteristic features of the design shown in Fig. 50 are the cartouch *a* at the center of the panel, the trident *b* that pierces it, the dolphins *c* that act as supporters, and the scrolls *d*, which complete a very rich and artistic panel. This design for a stair rail is especially good, as it fills the void between the string and the rail, affording perfect protection, while at the same time the design is not overloaded with ornament and is very well constructed.

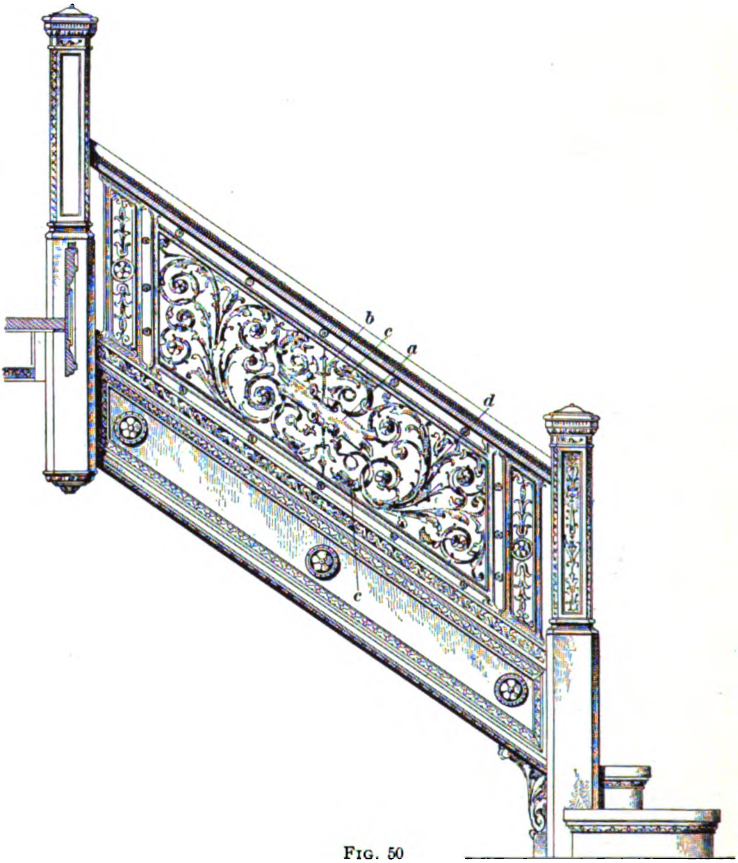


FIG. 50

The features of the railing shown in Fig. 51 are the long and the short panels forming its divisions. The large panels are strengthened and braced vertically at the middle with a post *b* running from the top rail to the lower rail, and horizontally with the rails *c*, *d*, and *e*. The short panel *f* is

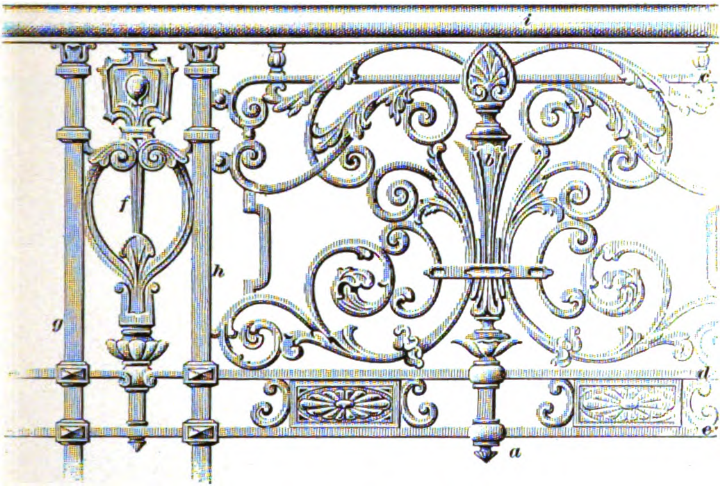


FIG. 51

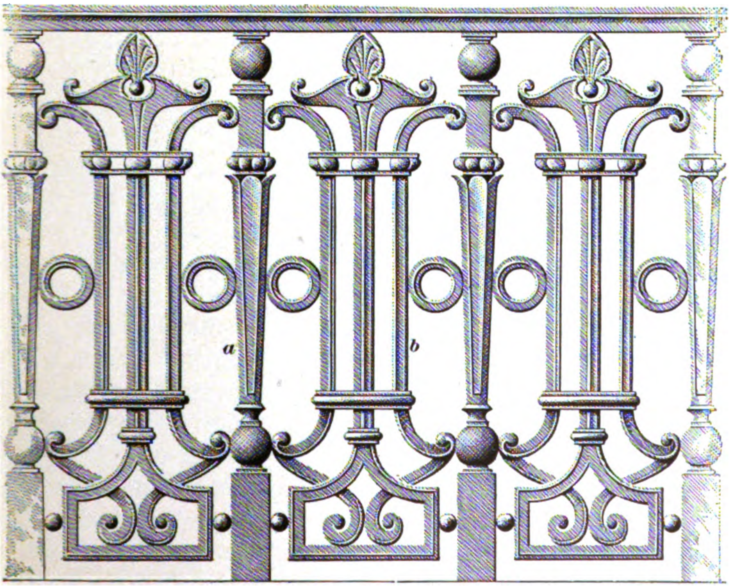


FIG. 52

let in between the posts *g* and *h*, combining them. The hand rail *i* is made of a brass or bronze pipe.

The rail shown in Fig. 52 is composed of a series of balusters *a* with panels *b* let in between them. The panel is well secured at four points on each side. The hand rail is formed of iron with a molded cap piece screwed on.

46. All of the foregoing stairs are such as might be used in ordinary office buildings or hotels, and having mastered the constructive details of these examples, it is possible to design any stairs, no matter how elaborate or massive. The character of the stairs should, of course, harmonize with the surroundings, and the principal flight, starting in the main hall, is often made a feature of the architecture by being of ample width and large proportions. The newels also can be treated in a special manner, and possibly the strings may be of wrought iron faced with ornamental cast iron. If the stairs are over 5 feet in width, it is necessary to introduce intermediate strings or supports to carry the load. Fig. 53 shows a florid design for a starting newel, which might properly be used for an important stairway.

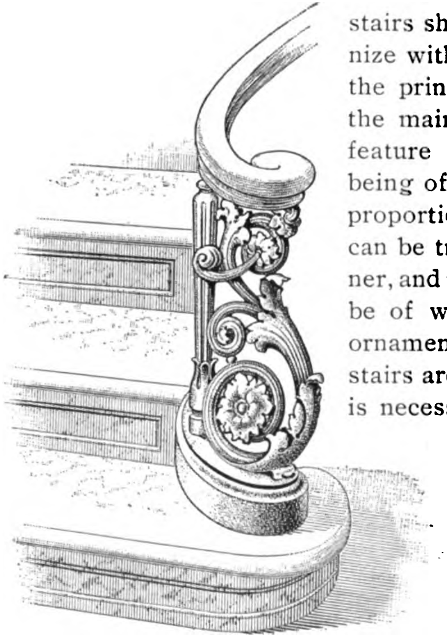


FIG. 53

Fig. 54 is reproduced from a photograph of a staircase with adjoining elevator enclosures. This is a good example of the style of stairs used in a typical office building. The effect of the decoration on the newels and strings and the repeating of the baluster panels of the stair railing are particularly good.

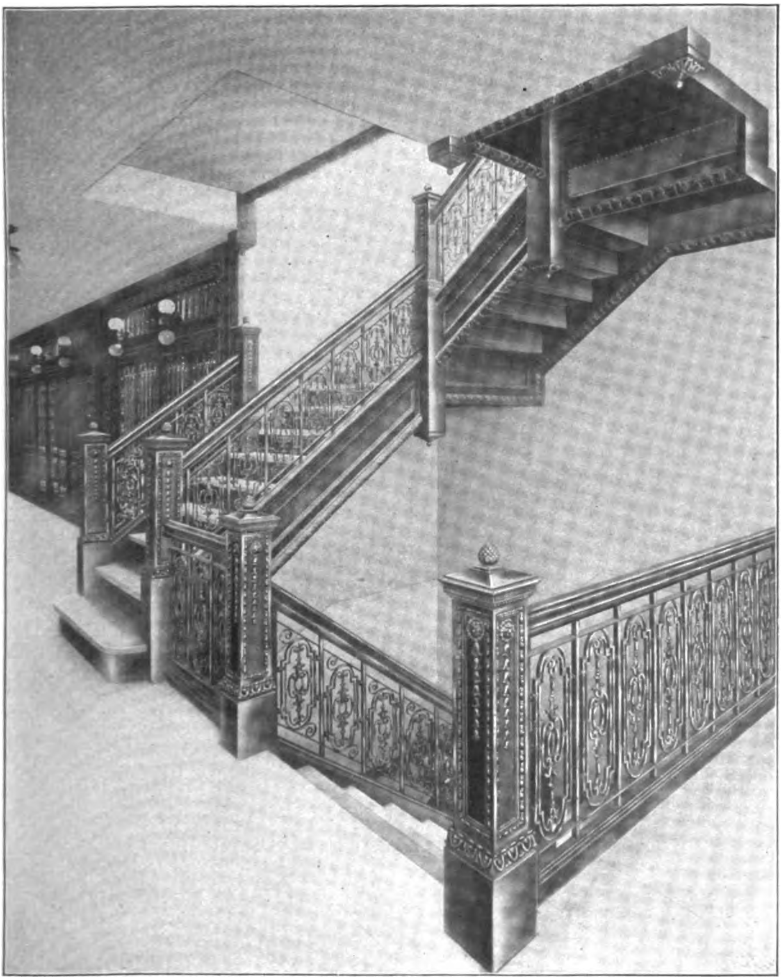


FIG. 54

BRONZE WORK

INTRODUCTION

47. Bronze.—The material known as **bronze** differs from iron in being an alloy of copper, tin, and zinc. It is softer and richer in appearance, and possesses many qualities that make it one of the most valuable metals for certain purposes. As bronze does not rust like iron, it may be used in conjunction with fine stone or marble without any danger of causing discoloration. It is capable of being finished in many ways, and its appearance, instead of becoming impaired, improves with age. The process of casting bronze is very similar to the process of casting iron, except for statuary and work of a similar nature. Bronze, however, shrinks to a greater degree than iron, and for this reason greater allowance has to be made.

48. Finishing Bronze Casting.—The amount of time and skill that may be expended in finishing and chasing bronze is practically unlimited, but depends entirely on the article itself and on the position it is to occupy. A cornice or cartouch, say on the façade of a building at a considerable height above the ground should not be finished in the same manner as a counter screen for a bank, but, rather, it should be left somewhat rough, just as it comes from the sand, the effect being better. On the other hand, when a fine finish is desired, it is filed and rubbed with fine emery and chased until almost every part of the surface has been carefully treated, the difficulty often being to decide just at what point to stop. Many fine castings are robbed of all character by overdoing the finishing.

Bronze and iron can be worked in a somewhat similar manner, except that bronze does not act in quite the same

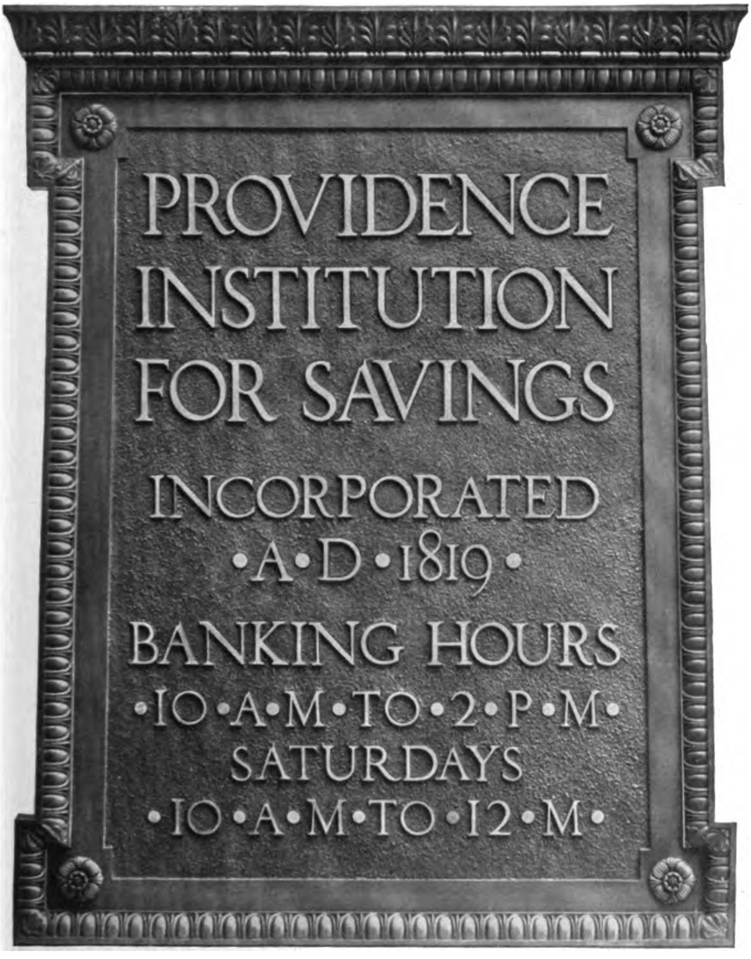

PROVIDENCE
INSTITUTION
FOR SAVINGS
INCORPORATED
•A•D•1819•
BANKING HOURS
•10•A•M•TO•2•P•M•
SATURDAYS
•10•A•M•TO•12•M•

FIG. 55

manner as iron when subjected to heat; it also presents difficulties that have to be overcome by repeated heating and careful working. Hammered work is done cold, the same as iron, but as bronze is softer and more ductile, it is easier to work.

EXAMPLES OF BRONZE WORK

49. Tablets and Cartouches.—Bronze is largely employed in the forms of moldings, capitals, and bases of columns, tablets, cartouches, etc. Fig. 55 is a design for a plain memorial tablet cast in one piece; or, if preferred, the letters may be made and applied separately. These tablets are usually fastened to brickwork or stonework by means of bronze expansion bolts with flat countersunk screw heads, which are tapped and covered with a rosette or button that screws into the hole in the bolt head.

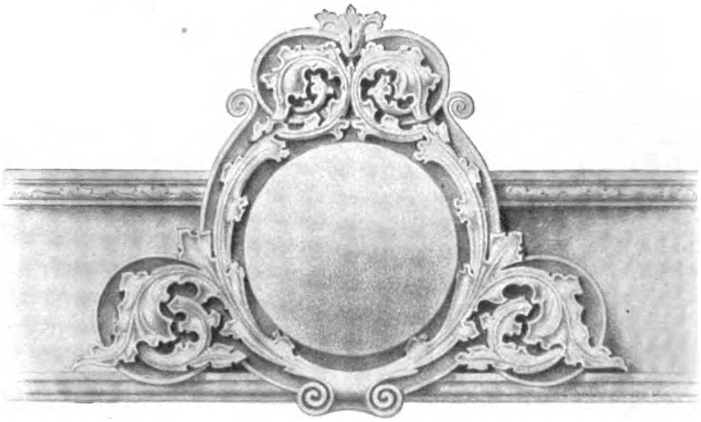


FIG. 56

Fig. 56 is a cartouch somewhat after the Italian Renaissance style, and marks the middle point of the frieze on which it is set. Possibly it might be placed over an entrance or on one of the stone piers of a building or any similar spot. The modeling may either be in very low relief or project boldly. If the latter, it is likely that the hollows would be undercut, and proper arrangements for this should be made in the pattern.

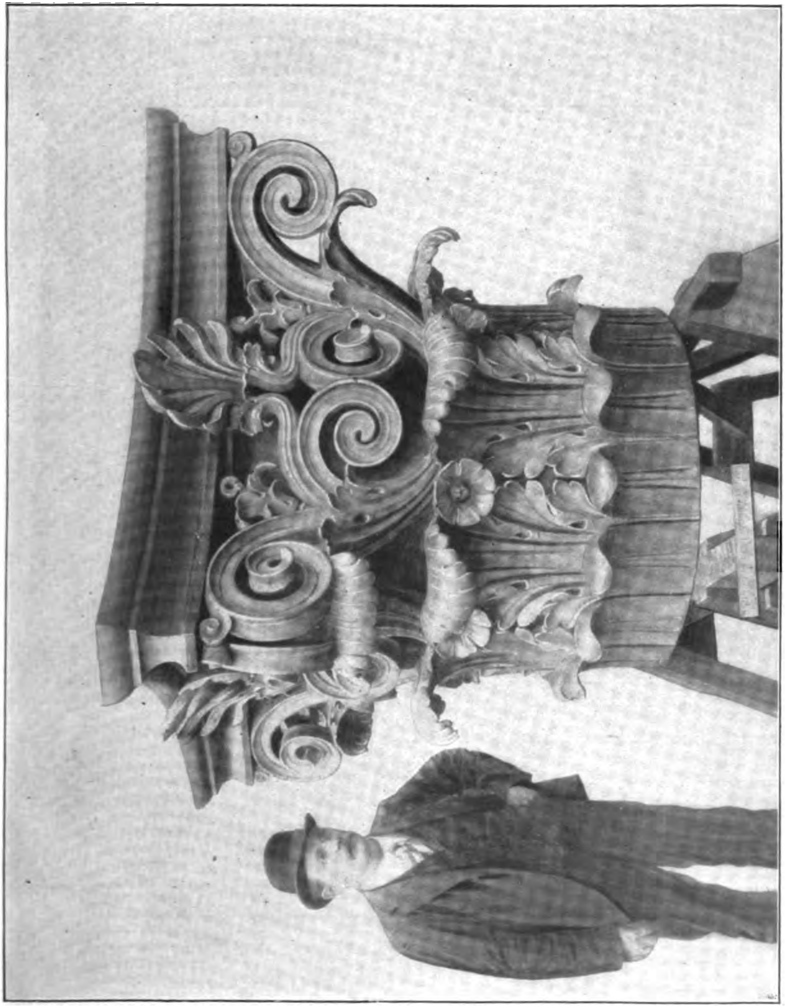


FIG. 57

50. Bronze Capital.—Fig. 57 represents a large Grecian Corinthian capital elaborately undercut, almost every separate member standing out free from the body. This body, or central part, is made separately as is also the abacus, and the individual scrolls and leaves are mounted on it one after the other. As a matter of fact, the whole capital could be cast in one piece if necessary or desirable, but would involve considerable expense and risk; therefore, the best plan would be to build it up in a number of units.

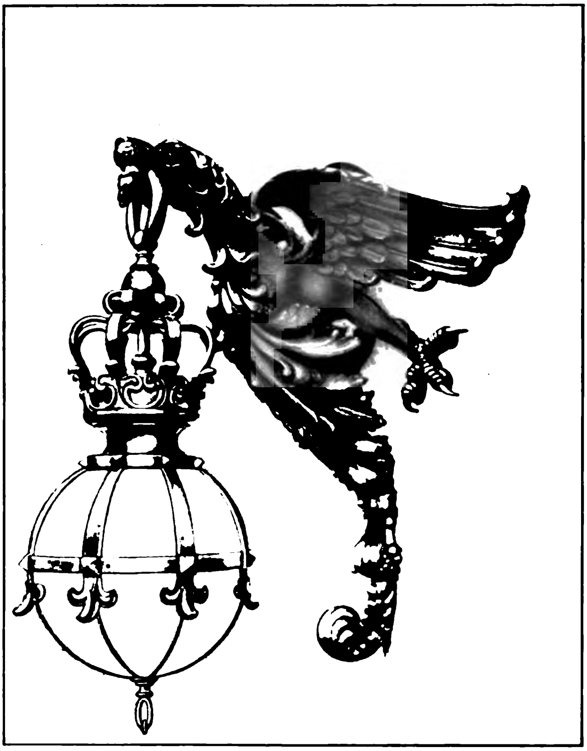


FIG. 58

51. Brackets and Lamps.—Bronze work as applied to lamps and brackets is susceptible of very beautiful treatment, of which Fig. 58 is a striking example. This figure illustrates one of a pair of lamp brackets in the form of a griffin

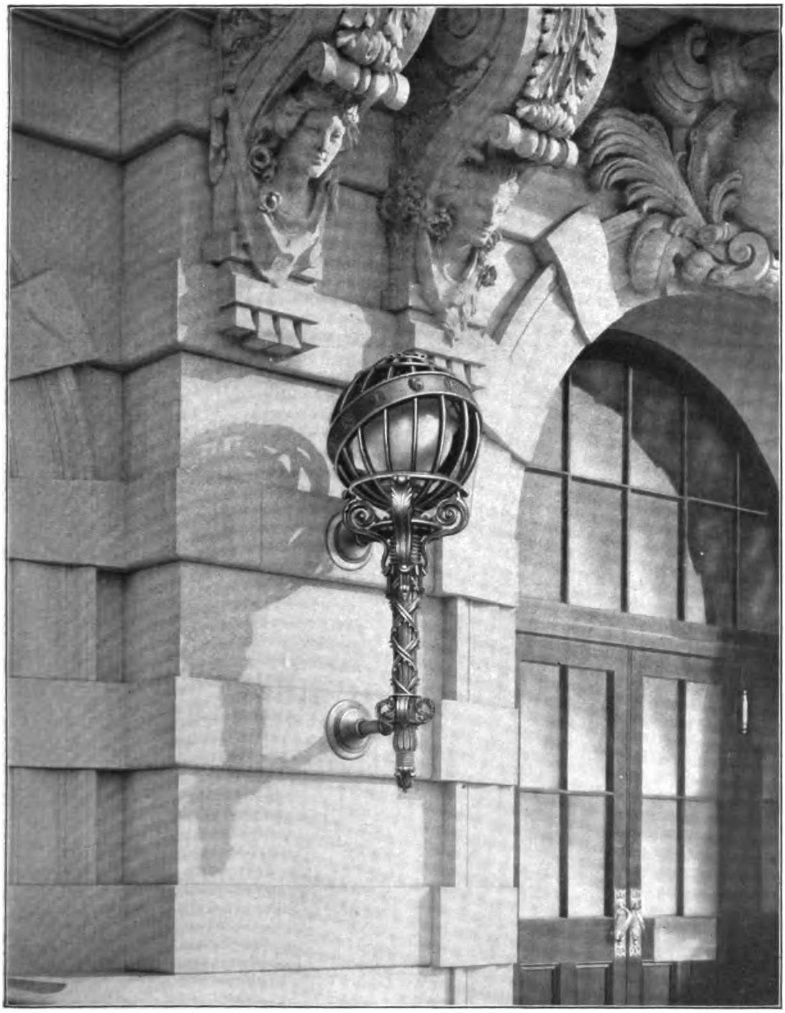


FIG. 59

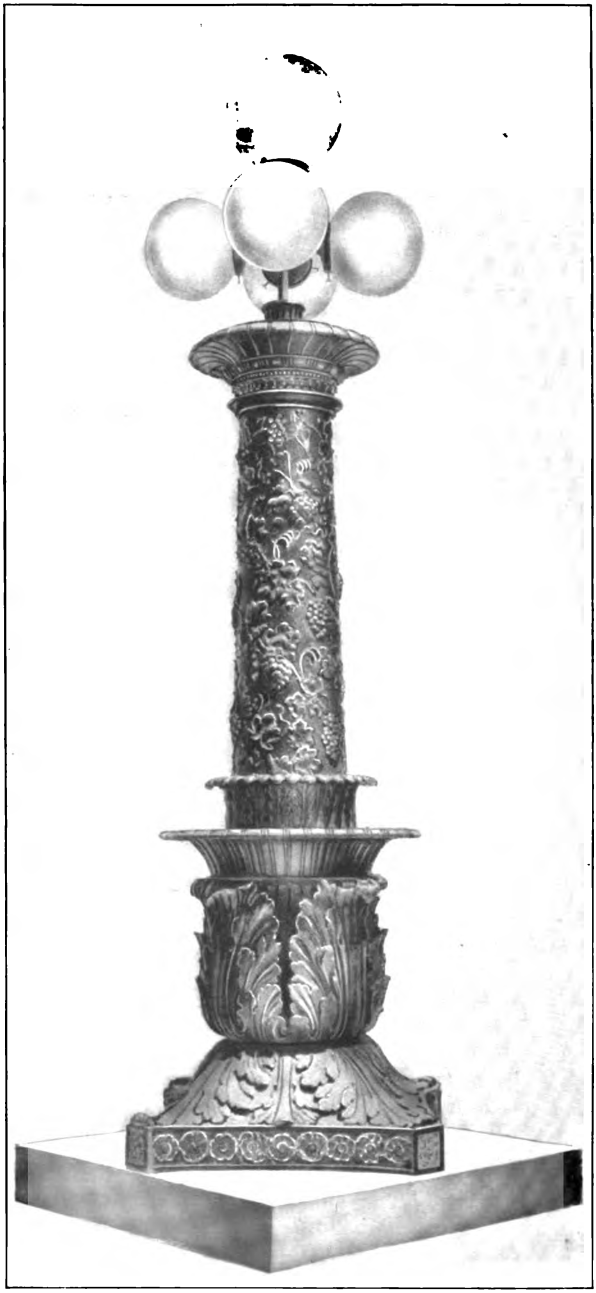


FIG. 60

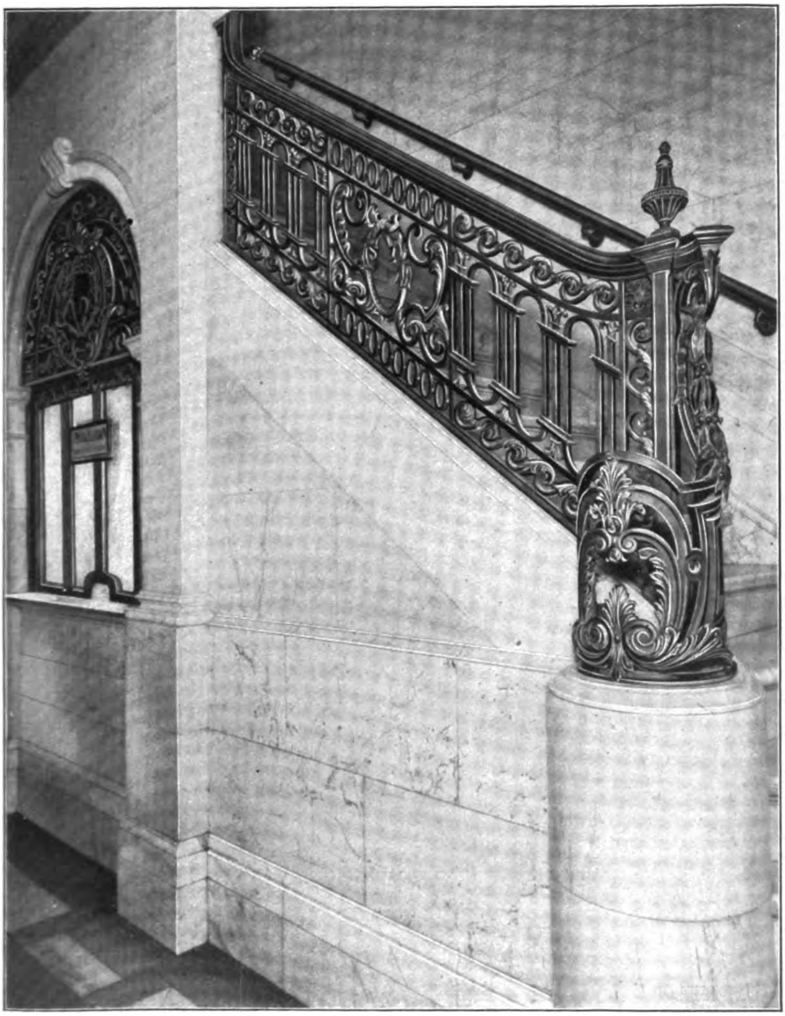


FIG. 61

with outstretched wings and bearing the globe depending from its jaws. The combination of utility and beauty are well worked out, in that the bands around the globe are kept entirely on the upper part so that the light is not obstructed in a downward direction, where it is most desirable. The whole pose of the body is strong, and the effect is brisk and lively.

Another beautiful design having the shape of a torch supported from the wall on two straight arms is shown in Fig. 59. This design is totally different from the preceding one, as it is almost purely decorative. The element of light is used only as part of the general scheme. The light is surrounded by a skeleton globe with an equatorial band on which are the signs of the zodiac. It was designed for the office building of the American Geographical Society.

52. Lamp Column.—In Fig. 60 is illustrated another type of lamp, being a standard or column rising from a base and resting on a stone block. The modeling of the acanthus leaves and the trailing vine is exceptionally good, as are also the general proportions.

53. Newels.—Fig. 61 shows the starting newel and part of the railing for a marble stairway suitable for a bank or private residence. The effect of the curved newel with the trailing leafwork circling around on top of the marble base adds greatly to the appearance of the hall in which the stairway is placed.

A similar effect is shown in Fig. 62. The design in this case is marked by great solidity and massiveness. The stair string here is also of bronze, although the weight of the stairs is borne by a steel beam or channel behind the bronze string, being concealed by the string and the marble work.

The character of the design in both examples is determined by the hall, which in the former case is comparatively small and dainty and in the latter, lofty and spacious.

54. Elevator Screens.—Fig. 63 shows a bronze elevator screen, the transom grille being designed to contain the dial indicator, which shows the movement of the elevator car as

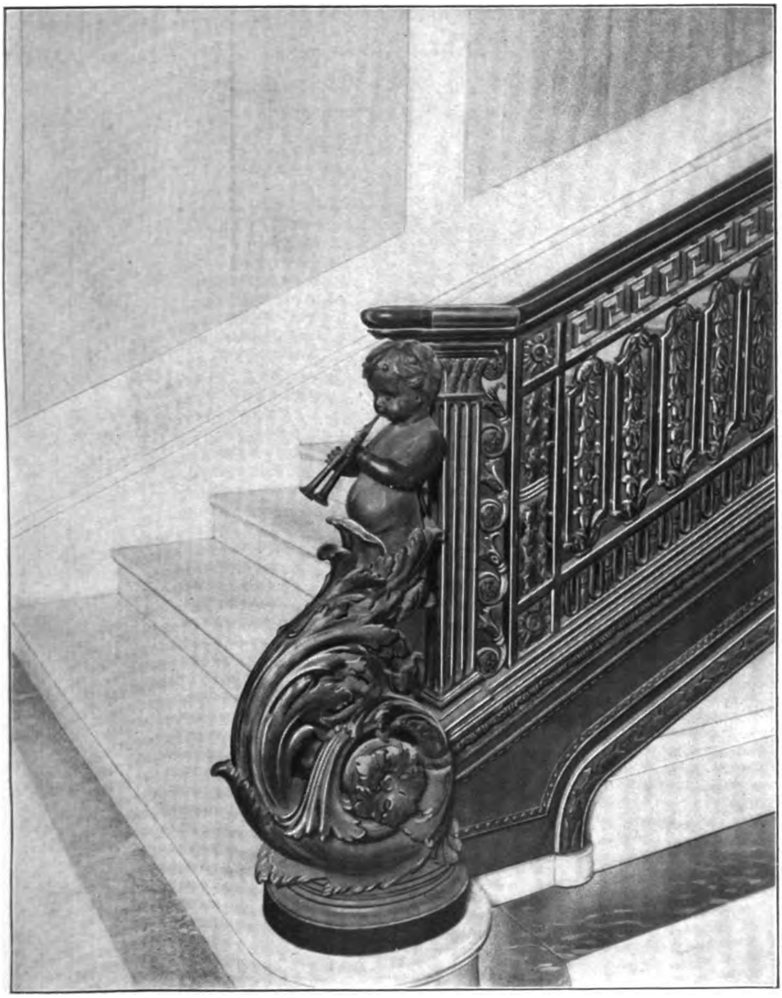


FIG. 62

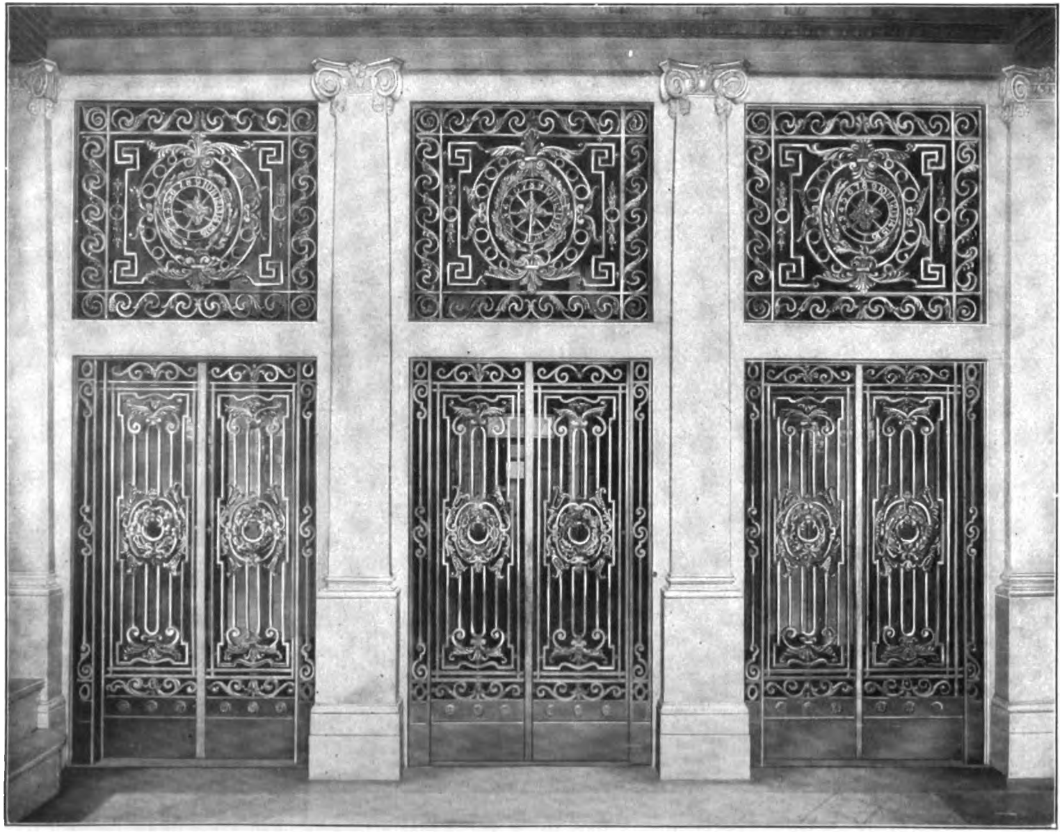


FIG. 63

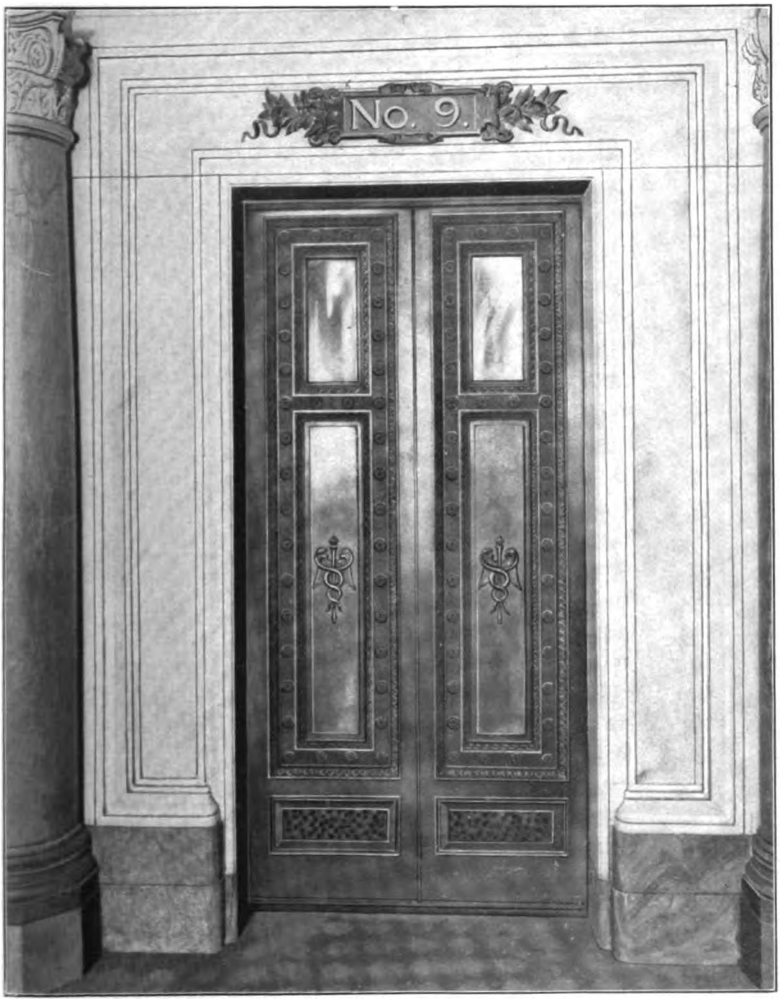


Fig. 61

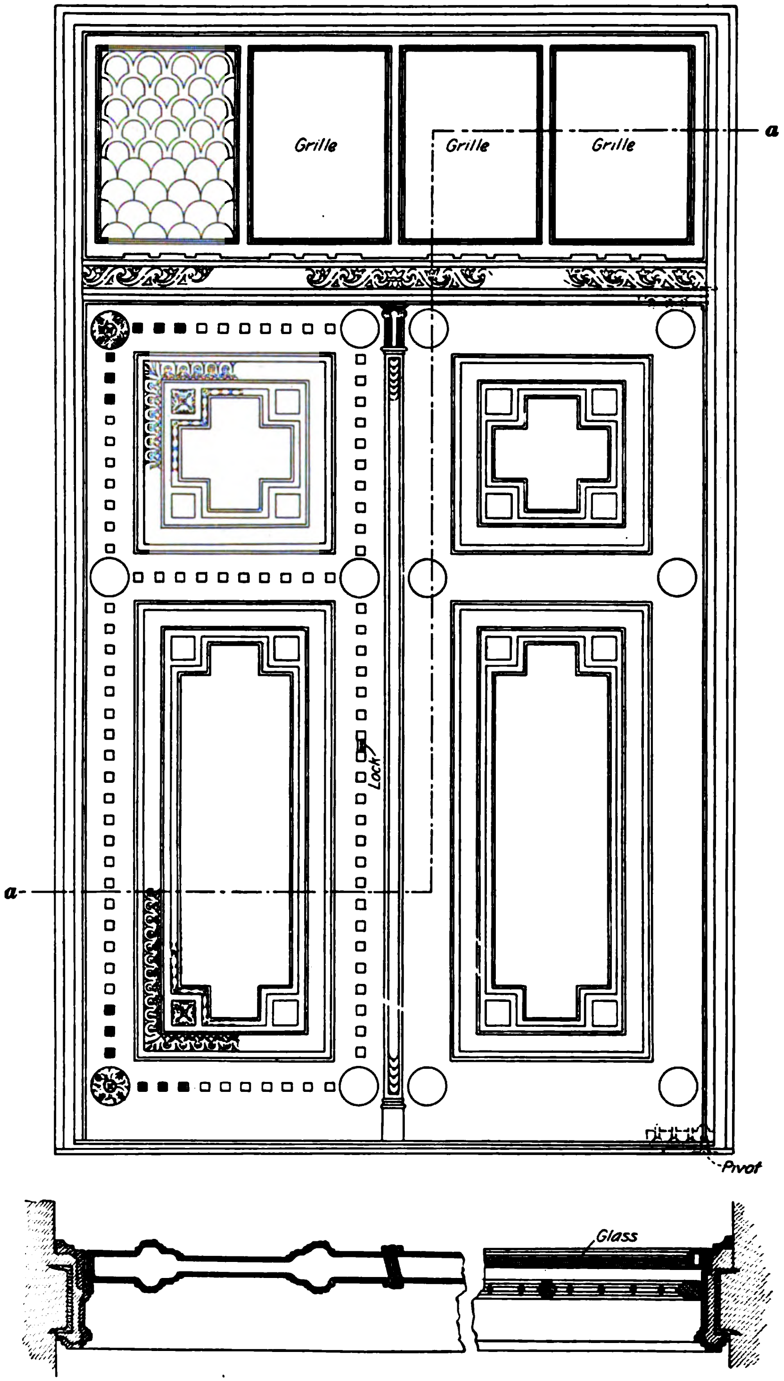


FIG. 65

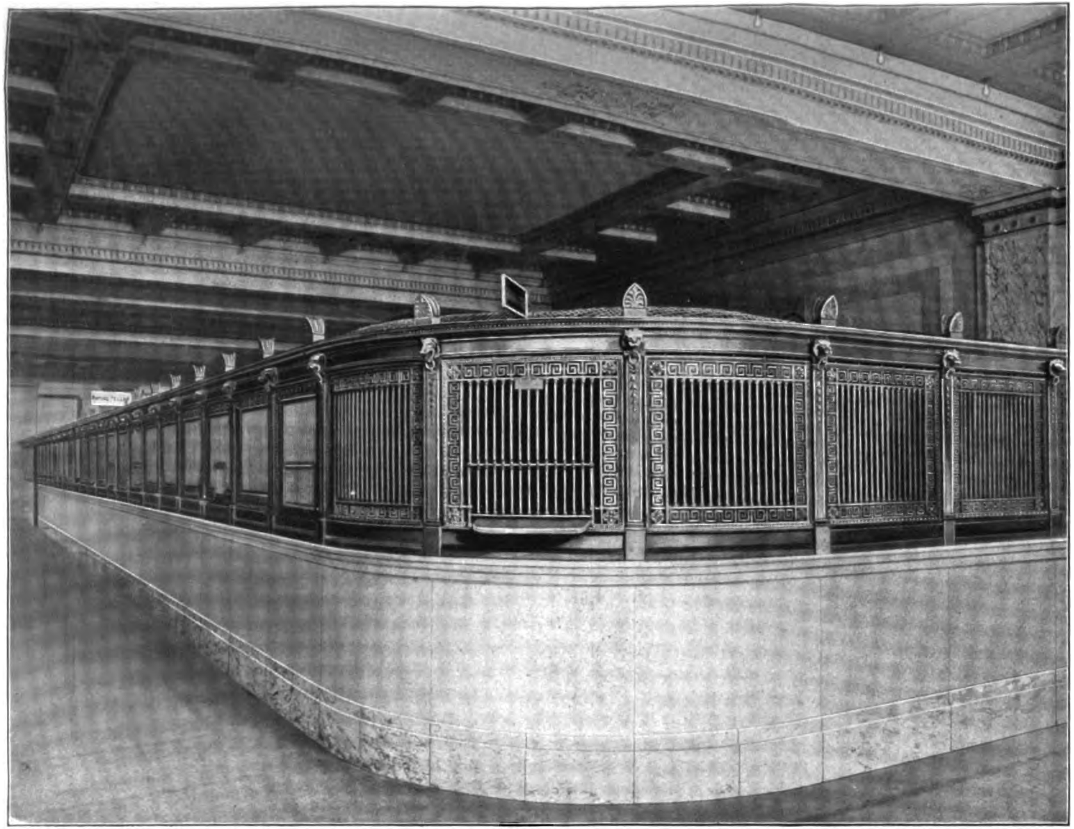


FIG. 66

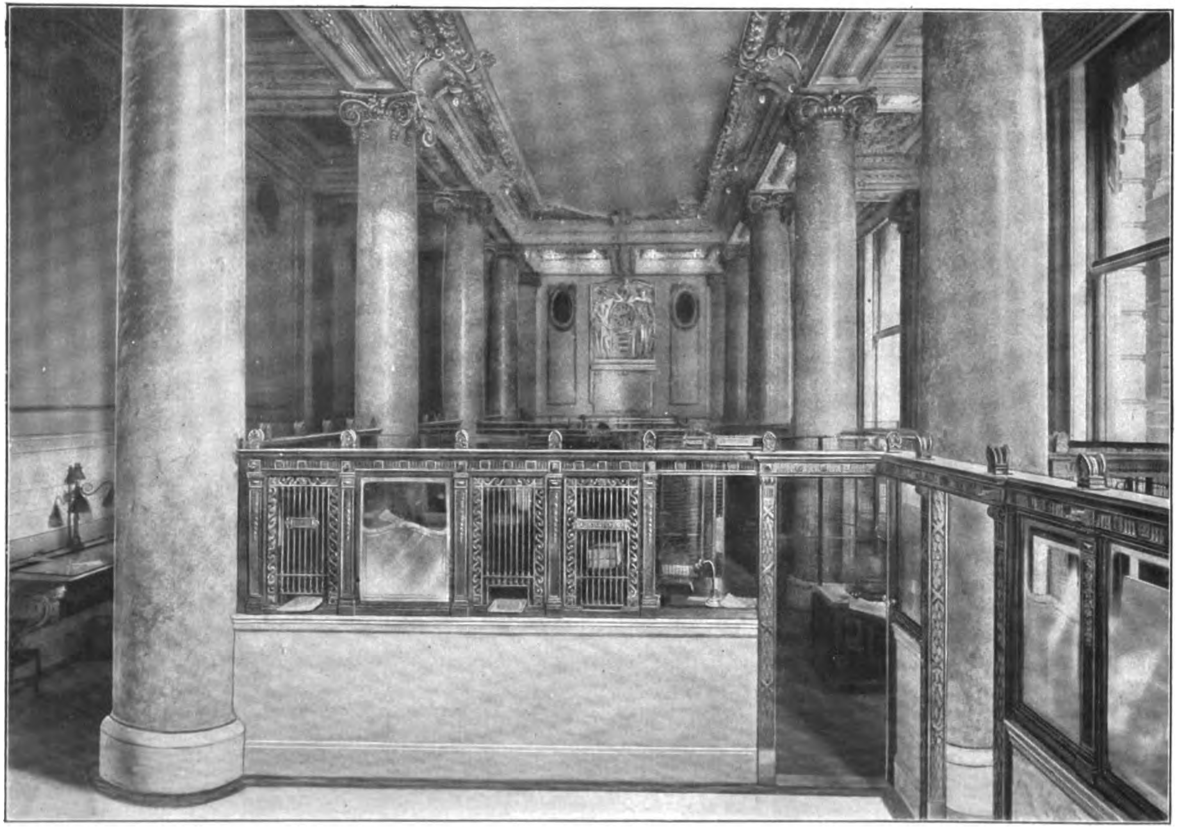


FIG. 67

it travels up or down. This design is for a combination of wrought and cast bronze, the straight bars being wrought and the scrolls and leafwork cast.

This screen could just as well be made of either all wrought or all cast bronze. If of the latter, however, the work of filing and finishing the straight bars would be greater, and the result would not be so satisfactory. As to which parts of any design shall be cast and which wrought, is to a great extent a matter of expediency, the artisan using his own judgment as to what is most convenient.

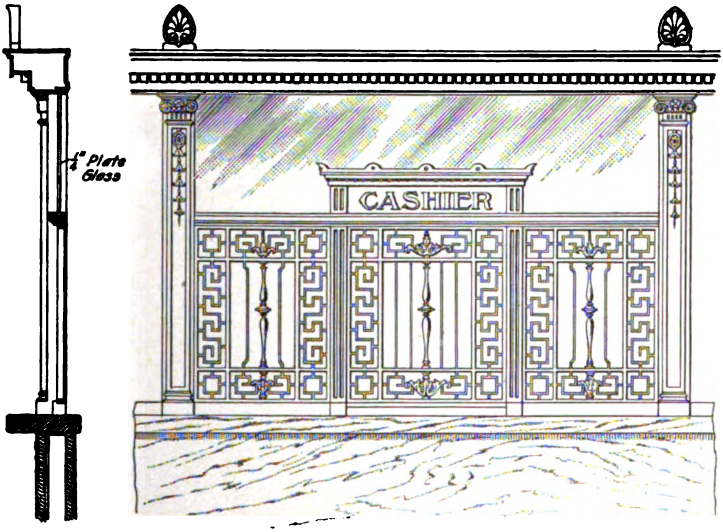


FIG. 68

55. Doors.—Entrance doors are made of bronze in many designs, depending on the style of the building in which they are to be used. Some are in grille form with glass panels, and others are solid, like Fig. 64, with the upper panels glazed. They may be cast or built up out of sheet bronze planted on a wooden core or on an iron or bronze skeleton frame, in which case the moldings and ornaments are applied separately. The fitting and jointing should be carefully done, so that the work as a whole may look solid.

Fig. 65 shows a similar pair of doors, but with a transom light overhead, the glass being protected by a heavy grille. In order that the glass may be cleaned, it is set in a separate frame, which may be hinged at the top or bottom, or, if preferred, at the sides. This door is shown as a solid casting, but may be built up as before mentioned.

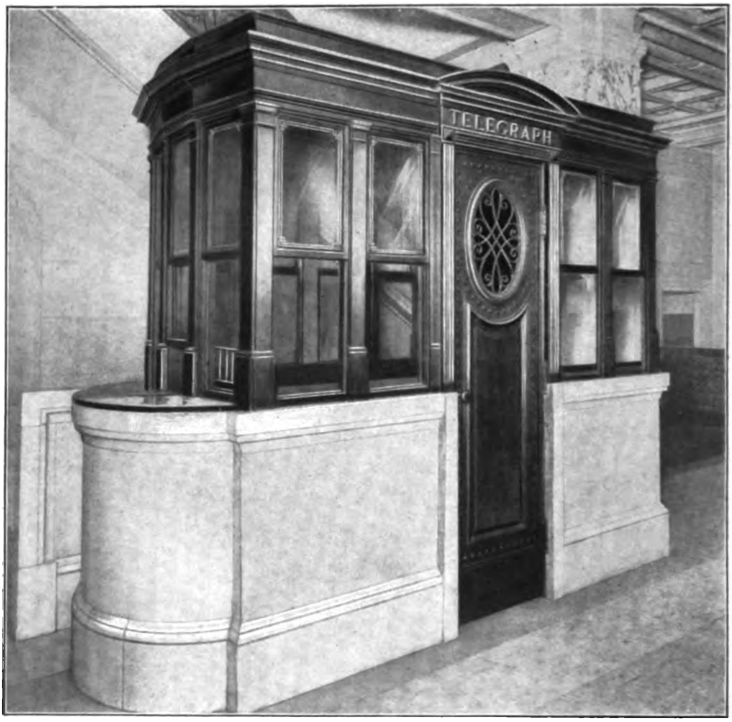


FIG. 69

56. Counter Screens.—Figs. 66 and 67 illustrate counter screens for banking rooms, and are designs of exceptional merit. These screens are made chiefly of cast bronze. In every case, the paneling is backed up with plate glass, which may be clear, frosted, or decorated in any manner desired. Fig. 68 shows another design in which the grille-work is lighter and is made of wrought bronze. The section shows how the whole screen is supported by a skeleton wrought-iron frame concealed by the marble panels of the wainscot. The bronze posts have a wrought-iron rod running through them and bolted to the angle framework, in order to insure rigidity. The wickets in front of the officers' desks are, of course, hinged so as to open.

57. Telegraph Booth.—Fig. 69 shows a complete telegraph booth constructed of bronze and marble. The construction is somewhat similar to that of the counter screen. As the marble, being in slabs about $\frac{7}{8}$ inch thick, has very little bearing strength, the weight has to be carried by some kind of framework, preferably wrought iron.

As has already been stated, almost any of the iron examples may be made in bronze, the chief difference in execution being the amount of time expended in finishing the work.

ORNAMENTAL METAL WORK

(PART 2)

WROUGHT-IRON WORK

METHODS OF MANUFACTURE

CHARACTERISTICS

1. Wrought iron and steel differ from cast iron principally in the characteristics that they are soft, malleable, and fibrous, while the latter is hard, brittle, and crystalline. This difference in character is due to the method of manufacture, as both kinds of material come originally from the same ore. Wrought iron and steel are purer than cast iron, as phosphorus and sulphur are eliminated as far as possible, as well as other ingredients that abound in cast iron. It is the carbon that gives cast iron its hardness, and the phosphorus that makes it brittle, while the elimination of the sulphur renders wrought iron malleable and capable of being forged. While it is practically impossible to entirely eliminate these ingredients in the manufacture of wrought iron, they may be so reduced as to be harmless. The presence of too much phosphorus will render the iron what is termed **cold short,** that is, brittle, or liable to split or break when hammered or bent cold. Sulphur, however, does not so much affect the cold working of the iron, but if present in excess, it tends to make it **hot short,** or brittle at a red heat, and unweldable at any temperature.

The value of these characteristics will be better appreciated when the methods of working are described.

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TOOLS AND IMPLEMENTS

2. In some structural work, cast iron is used extensively on account of its cheapness; but for certain classes of work, cast iron is not suitable, and wrought iron is employed almost exclusively.

Ornamental wrought-iron work may be divided into two general classes; namely, that which requires to be fashioned while hot, and lighter work, which is manufactured from cold materials. In each case, the original material is in the same form—long bars of varying widths and thicknesses, which are worked with vise and pliers, or forged with hammer and anvil, into any desired shape. The dominating feature of some designs is frequently the repetition of similar scrolls or rings; and when there are a number of these, it is necessary that they should be produced rapidly and exactly alike.

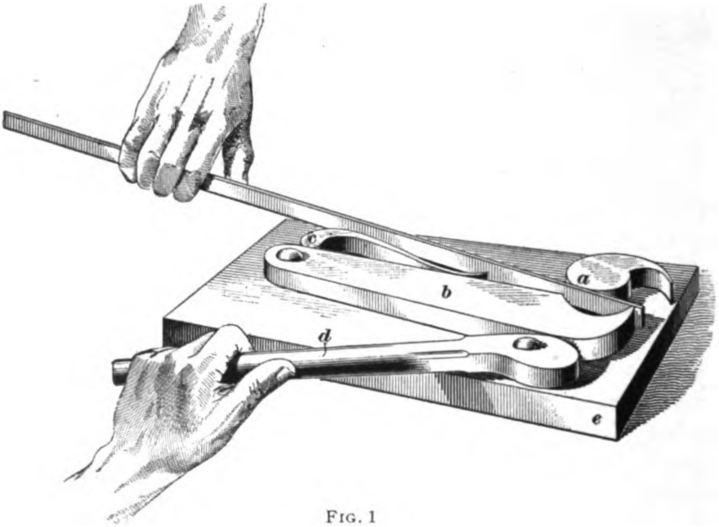


FIG. 1

In making any small scroll of light iron, the first and most important step is the forming of the small quirk, or curl, at the center; the method and machine for doing this is shown in Figs. 1 and 2. The tool employed is of a very simple character, and consists of a templet *a*; a clamp, or die, *b*, which is pivoted at one end, the other end fitting over the templet; a spring *c*, which keeps the die clear of the templet; and a lever *d*, which forces the die into place. In Fig. 1, the lever is thrown back to allow the clamp to be pressed open by the spring *c*. The bar, the end of which is to be bent, is introduced between the templet *a* and the clamp *b*. The lever is then pulled forwards, forcing the die against the templet, and the beginning of the scroll is formed. The bar is then brought around to the position shown in Fig. 2, and the first convolution of the spiral is completed.

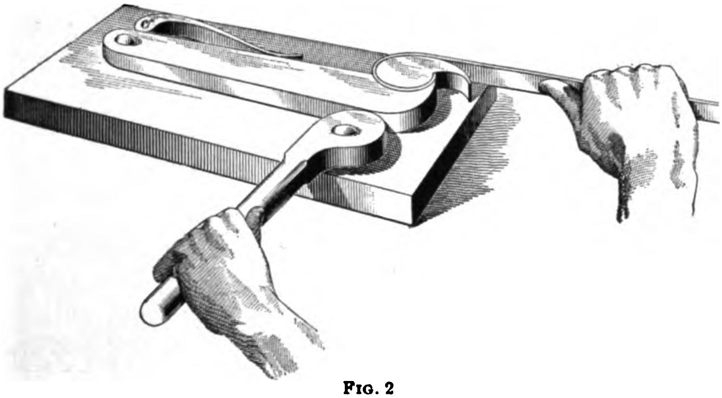


FIG. 2

3. The bar is now placed in the machine shown in Fig. 3, and the remainder of the scroll is formed. This machine consists of a shaft *a*, on which a screw thread is cut, and over which is coiled a steel spring *b*. On one end of the shaft is a crank, or handle, and on the other end the disk *e* carrying the coil, or volute, *f*, which forms the die, or pattern, for the rest of the scroll. This plate and volute are detachable, so that different sizes of scrolls may be formed on the same machine.

The bar, having had the first convolution of the scroll formed as already described, is now placed in the machine, as shown at *h*. The lever *g* is pressed against it to hold it in close contact with the volute *f*, and the disk is revolved until the scroll has assumed the proper number of convolutions.

As the shaft turns, the screw thread causes the disk to advance, and the bar *h* is coiled evenly in one plane, instead of conically, as might appear from the spiral on the disk. As the disk advances, the edge of the spiral in contact with the lever *g* is always in the same relative position. When the shaft has reached the point where the proper number of revolutions has been attained, a catch releases the nut from the screw thread, and the spring *b* throws the shaft and disk back to their original position, and releases the completed scroll, which is now cut off the bar, and another one prepared in the same manner.

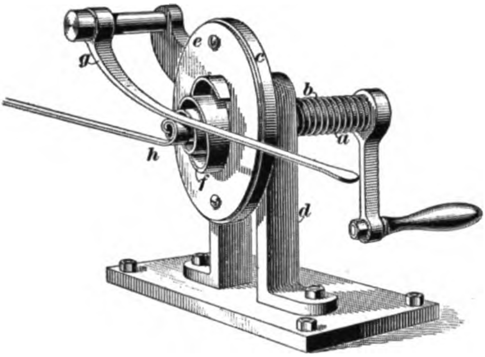


FIG. 3

With such appliances one man can make from 300 to 600 scrolls in a day, according to their size and weight; but where only a few scrolls are required, it is usual to make them almost entirely by hand, for which tools similar to

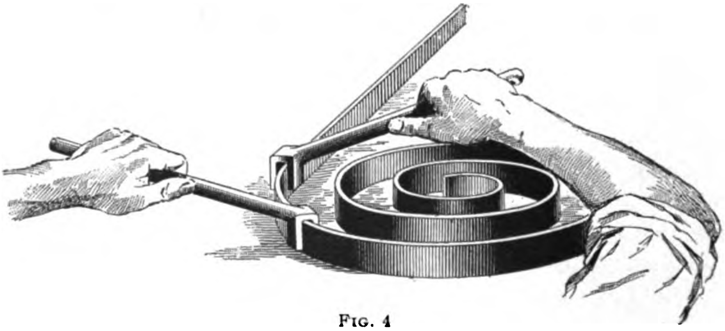
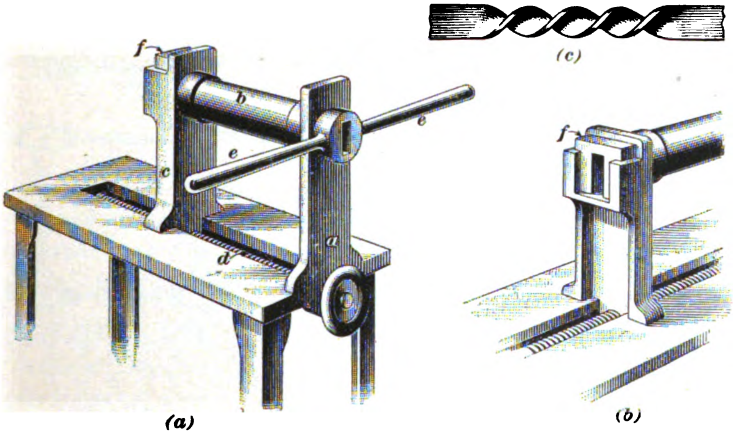


FIG. 4

those shown in Fig. 4 are used, the operation being so simple that description is not necessary.

4. As it is more economical to have special machines for the manufacture of scrolls in quantities, the same applies to the twisting of flat bars, and for this purpose the appliance shown in Fig. 5 (*a*) is used. This apparatus consists of a fixed upright *a*, with a socket to receive the pipe *b*, the other end of which rests in the movable upright *c*. The upright is arranged to travel along the bedplate by means of a threaded shaft *d*, so that the length of the pipe *b* may be changed to suit the length of the twist required to be produced. The bar to be twisted is passed through the pipe and the slot in the lever *e* until in proper position, after which the slotted piece *f* is dropped into the pocket, as shown in Fig. 5 (*b*). If the length of the pipe is such that the distance between the lever and the slotted piece is of the desired length for the twist, and the bar is then held at these two points and prevented from revolving independently, the lever can be wound around as many times as is necessary to produce the required twist. The greater the number of turns, the closer will be the twist. The piece *f* is made loose and dropped into place, so that it may be easily lifted out when the twist is completed, and thus allow the finished bar



(*c*)

(*a*)

(*b*)

FIG. 5

to be withdrawn without twisting in through the slot, as would be necessary if the slots were permanently fixed in each end. The pipe *b* merely acts as a guide to prevent the bar from bending in a lateral direction when the twist is of considerable length.

5. The machine just described is for making a regular twist, as shown in Fig. 5 (*c*), but another form of twist in common use, especially in light grille-work, is made by giving the bar a series of half turns, as shown in Fig. 6.

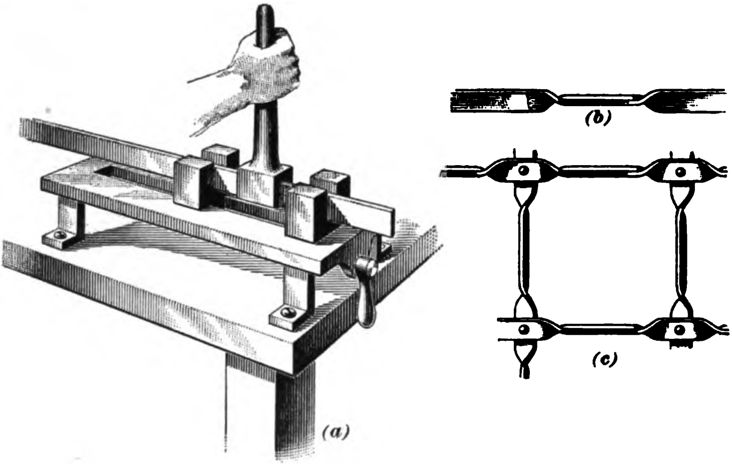


FIG. 6

The bar is dropped into two slots, as shown at (*a*), one of which can be adjusted by means of a long screw underneath the bedplate, so that the length of the part to be twisted may be regulated. It is then grasped between these slots by the loose clutch, and given a half turn, producing the result shown at (*b*). If the bar is to form a part of a square mesh grille, as shown at (*c*), there will be a number of these twists to each piece, and the distance from center to center should be marked out before the twisting is commenced. If the quantity required should be great, it might be advantageous to make a set of fixed pockets fixed to the proper centers, so that six or more turns could be made without lifting the bar.

The foregoing are a few of the tools used in the manufacture of light grille-work; where this class of work is produced to any great extent, however, there is a constant demand for new tools to meet the requirements of special conditions, but these tools cannot be bought and therefore must be made. It would be impossible to provide for the manifold variations that are likely to occur; but, apart from these special tools, those that are here illustrated are always in demand, and supplement the general machines, such as drills, punches, lathes, etc.

BAR ORNAMENTAL WORK

GRILLES

6. Simple Designs.—Having described the tools used in working wrought-iron bars into forms for grilles, a few examples of the simpler forms of grilles are shown in Figs. 7 to 10. These are plain basket patterns, and can be made from any size iron and set to any mesh. The frames are of angle iron, the ends of the meshwork being riveted to them. The meshwork grilles, being of an interlaced pattern, form a strong and economical screen to manufacture. If the surface to be screened by this basketwork is considerable, it is desirable to place rivets at intervals throughout the mesh; otherwise, the metal strips that form the mesh are likely to slip out of place and become distorted.

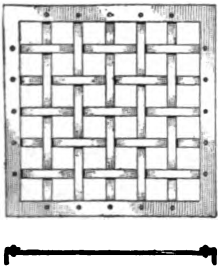


FIG. 7

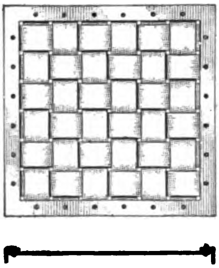


FIG. 8

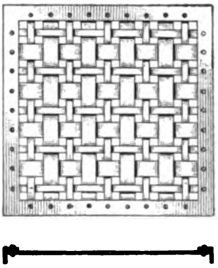


FIG. 9

If a more ornamental grille is wanted, the simplest variation is obtained by twisting the bars as shown in Fig. 11, the result being that a mesh is produced with the edges toward the eye and a series of flat crosses at the intersections. If a border to this grille is desired, the scroll ornament shown in Fig. 12 is suitable and inexpensive; a glance at the illustration will show that this scroll is made by simply turning the ends of each strip or bar. In this case, an angle-iron frame could not very well be used, because part of the scroll would be hidden by the flange of the angle. The frame may be a flat bar, though a small channel would be preferable, as the ends of the rivets that fasten the scrolls could be hidden in the hollow of the channel.

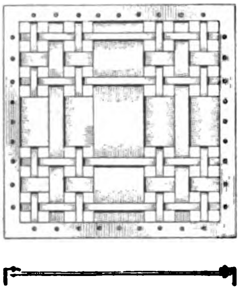


FIG. 10

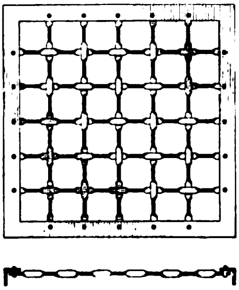


FIG. 11

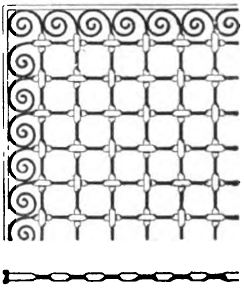


FIG. 12

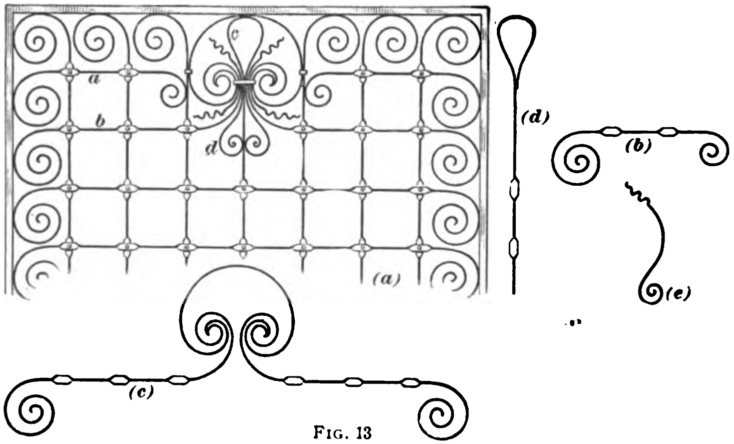


FIG. 13

7. A great variety of grille designs have the square meshwork shown in Fig. 11 as a basis, with additional ornament introduced at top and bottom, as shown in Fig. 13 (*a*), or with a border and center ornament, as in Fig. 14. It will be seen that the ornament is formed to a great extent by turning the ends of the bars forming the square meshwork into

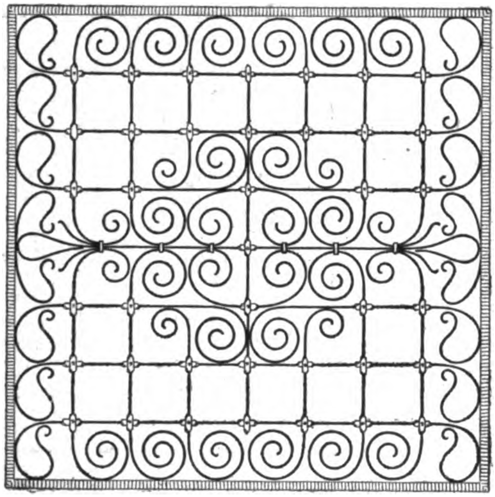


FIG. 14

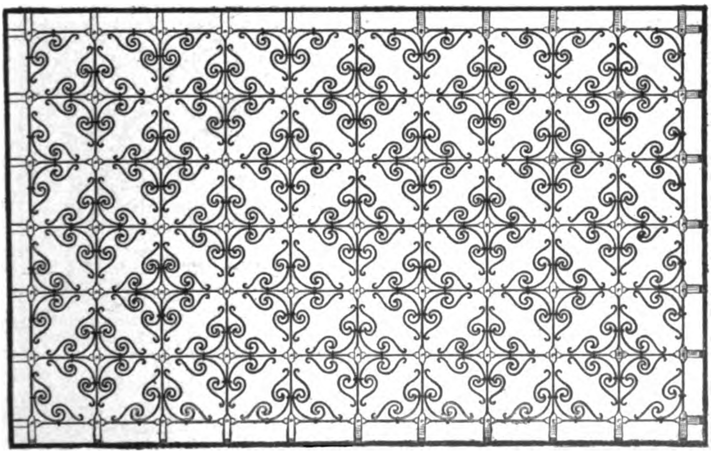


FIG. 15

scrolls, and adding other scrolls as may be desired. This can readily be seen by examining the designs shown, but to make it perfectly clear, some of the component parts of Fig. 13 (*a*) are shown separately. The small scroll *a* is shown separately at (*b*); the large central scroll *b* is shown at (*c*); the central division and loop *c* is shown at (*d*); and the small

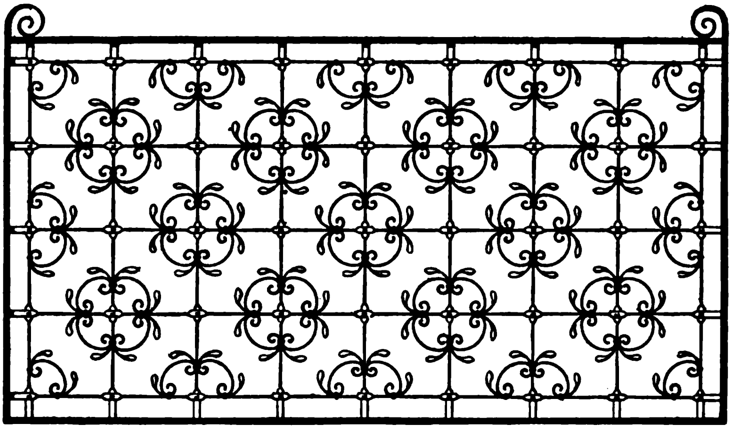


FIG. 16

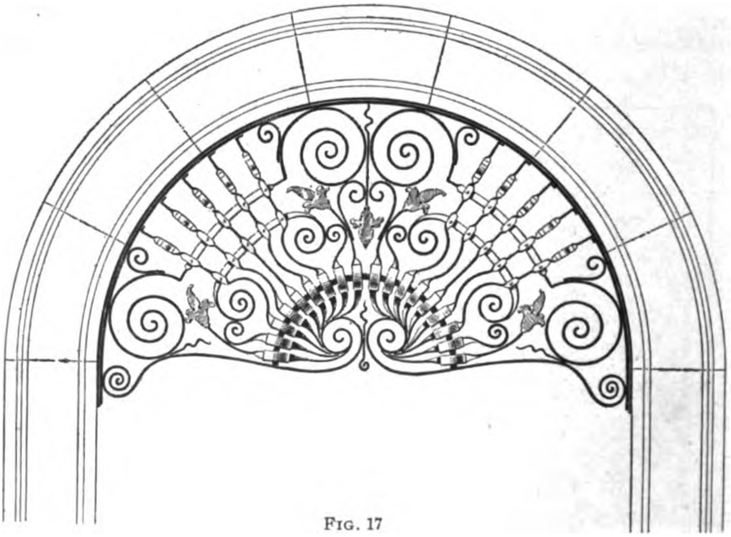


FIG. 17

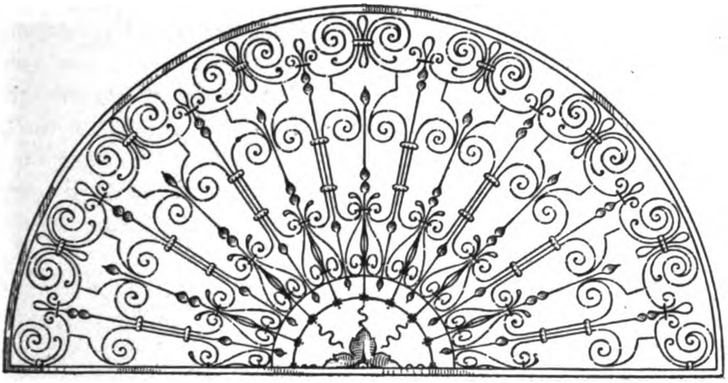


FIG. 18

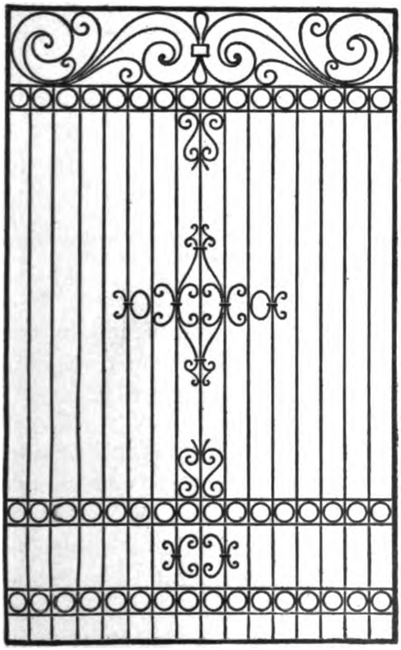


FIG. 19

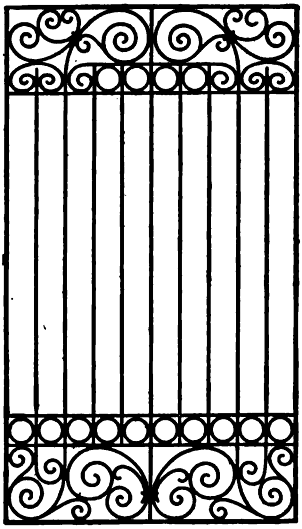


FIG. 20

scroll and ribbon *d* is shown at (*e*). These are all made of single pieces of iron.

The pattern shown in Fig. 15 is designed to produce a diaper effect, as is also Fig. 16, the latter being a more open pattern. All of these designs are for grilles made of light strips not over $\frac{1}{16}$ inch thick by $\frac{5}{16}$ inch wide, though at times heavier material may be employed. Figs. 17 and 18 are radiating designs suitable for arched window or door openings, but in other respects are precisely the same as the grilles just described.

In Figs. 19 and 20, the square mesh is abandoned, and the metal used is somewhat heavier, so that the long straight bars may be strong enough to resist the tendency to bend. There is no set rule for determining the size of iron of which a design should be composed, as this is governed principally by considerations of artistic fitness. If the iron is too thick to be readily twisted at the intersection, it may be half checked, as shown in Fig. 21; or, if one piece is wider than the other, the wide piece may be punched out to permit the narrower one to pass through it, as shown in Fig. 22.

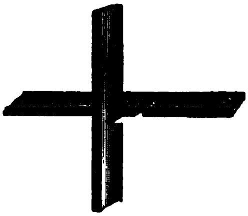


FIG. 21

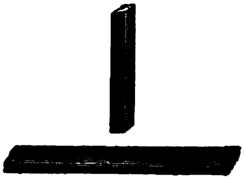


FIG. 22

8. **Office Grilles.**—The metal counter rails in banking houses, offices, etc., so far as the grille-work is concerned, are in no way different from the grilles heretofore described; but the arrangement of the supports, and the height and division of the rail, must all be proportioned to suit the special conditions of each case. Figs. 23 and 24 are examples of grilles made of cast and wrought iron. In Fig. 23, the rail and the posts are of cast iron, but the frame of the grille and the wicket gate and frame are of wrought iron. The grille

is a simple basket pattern of ribbon iron twisted at the intersections and wrought into scrolls at the outside to form a border. The main scrolls of the wicket are finished with cast-iron rosettes. The rail has a cresting produced by extending the post with a finial ornament, and placing a scroll each side of it.

The design shown in Fig. 24 is more elaborate. The posts and rails are of cast iron, as in the former case, as well as the frame surrounding the wicket gate; but the entire screen

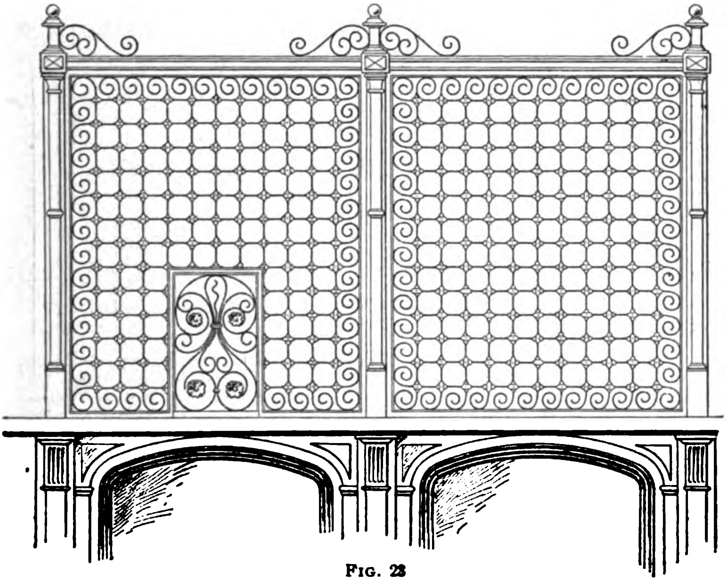


FIG. 23

is backed up with plate glass. The posts have a fluted band above the base, and just above this is a band, or circle, to carry out the line of the baluster rail of the screen. The entire grille of each panel is set in one frame, which is divided into two parts, the lower part forming a balustrade design, and the upper part a diaper; the loop scrolls of the diaper are ornamental with a pendant of leaves, as shown. The frame is separated from the rail, counter, and sides by button washers as shown. The plate-glass panels back of the screen are set in an angle-iron frame fitted with hinges that swing inwards, so that they may be opened to clean the glass. The wicket frame is designed with architraves and lintel, as would be any door or window. The change shelf under the wicket is made of heavy plate glass on a polished metal plate supported on two console brackets, and is fastened to the plate with countersunk screws through the metal plate. The head of the opening is ornamented with a cast-iron scroll and leaf, but the scroll at the junction of the frame and the baluster rail is of wrought iron, and is placed there to give rigidity to that point.

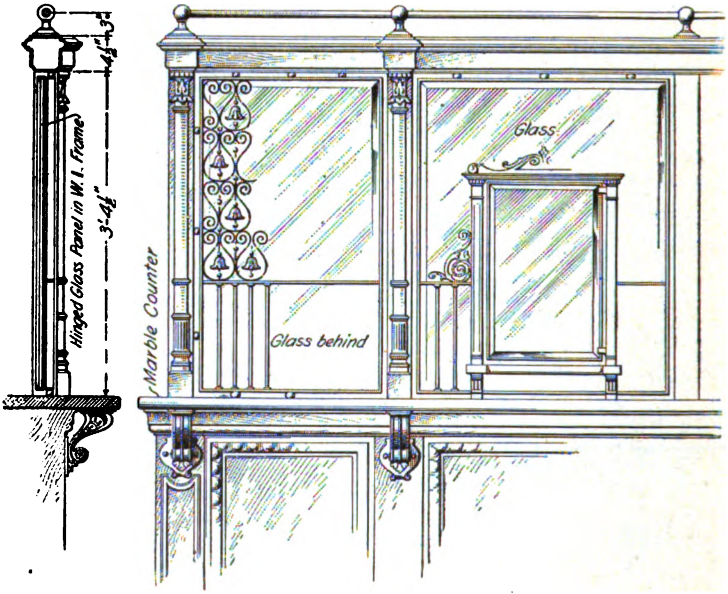
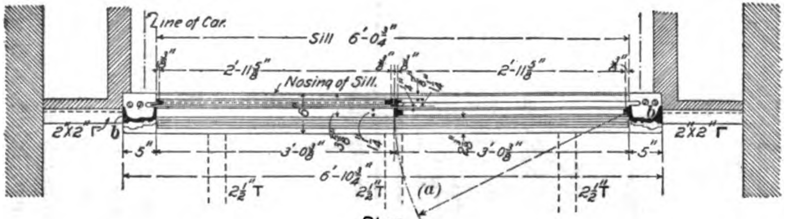
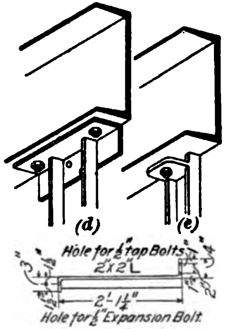


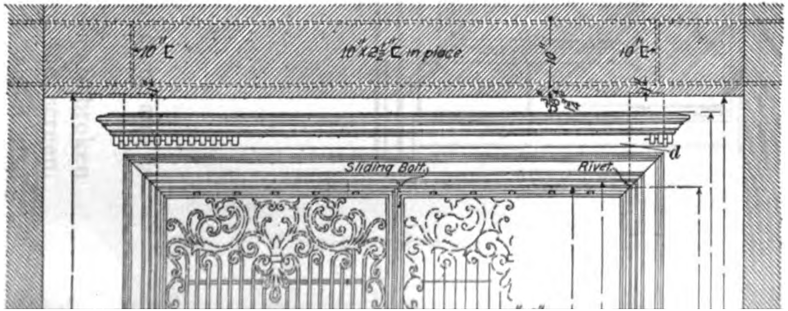
FIG. 24

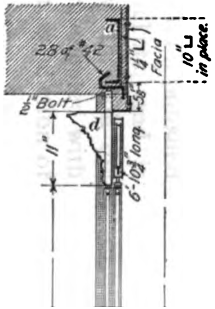
The moldings of the rail at the top of the screen are broken around the post to emphasize the divisions of the screen. Over each of these points is a finial ornament, which also serves as a standard through which the brass upper rail passes. These examples represent the usual forms and outline of this class of work, but the details of the design will vary with each individual case.

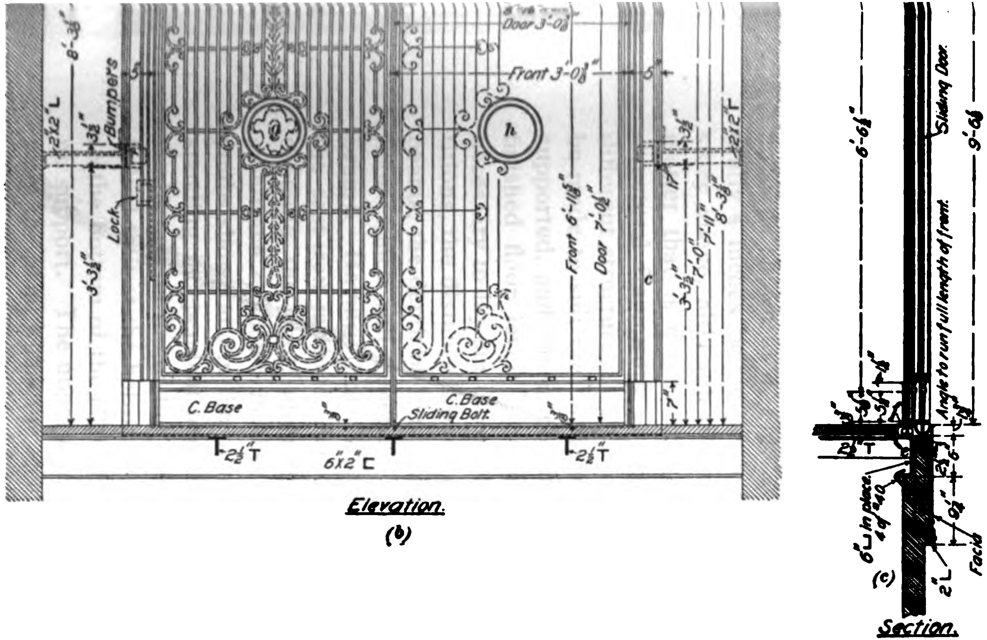

Line of Car.
Sill 6'-0 3/4"
2'-11 5/8"
2'-11 5/8"
Nosing of Sill.
2"X2" ⌐ b
b 2"X2" ⌐
5"
3'-0 3/8"
3'-0 3/8"
5"
6'-10 3/4"
2 1/2" T
2 1/2" T
2 1/2" T
(a)

Plan.


(d)
(e)
Hole for 1/2" tap Bolts
2"X2" L
2'-1 1/4"
Hole for 1/2" Expansion Bolt
3"


10" C
10"X2 1/2" C in place
10"
10" C
Sliding Bolt
Rivet
d


a
2.8 #/1'
1 1/2" L
Facia
10" ⊔ in place.
Bolt
d
11"
6'-10 3/4" long



Elevation.
(b)

Section.
(c)

Fig. 25

ELEVATOR ENCLOSURES

9. All the preceding examples of grille-work are suitable for use in elevator enclosures or any similar screen work, and their application to such work will now be considered. In Fig. 25 is shown an example of grille-work front for an elevator shaft. The shaft is formed by the main well of the building in the rear, and fireproof partitions on the sides, the front only being of grille-work. An angle iron or a channel is usually set across the front of the well at each floor, as shown at *a*, Fig. 25 (*c*), the top of which is generally 4 inches below the level of the finished floor of the story above, although the location of these beams, being a matter that is determined in connection with the general structural framework of the building, varies materially in different structures. The enclosure work should, of course, be made to suit the positions of these beams on which it is supported, and the important point is their relation to the finished floor level. In fact, the principal measurements necessary to lay out the work are the width between the partitions, the distance from the finished floor to the top of the beams, the depth of the beams, and the height from floor to floor (which will generally be the same as from beam to beam). Having these points determined, the position of the cast-iron jambs *b*, Fig. 25 (*a*), should be fixed. In this example, the whole opening is surrounded with a cast-iron architrave *c*, shown in the elevation (*b*), consisting of the jambs shown at *b* in the plan, over which is set the cornice *d*, standing independent and distinct from the partition. The jambs rest on top of the steel channel *e*, Fig. 25 (*c*), and are bolted to it at the bottom; while the top is run up and bolted to the bottom of the channel *a*, as the partition itself affords no support. The upper portion of the jamb is checked back from the point where the architrave is mitered, to the bottom of the beam above, in order to permit the cornice to pass in front of it, and to permit it to be enclosed in the partition. The top connections may be made by riveting to the head of the jamb a short piece of angle iron, to project each side of

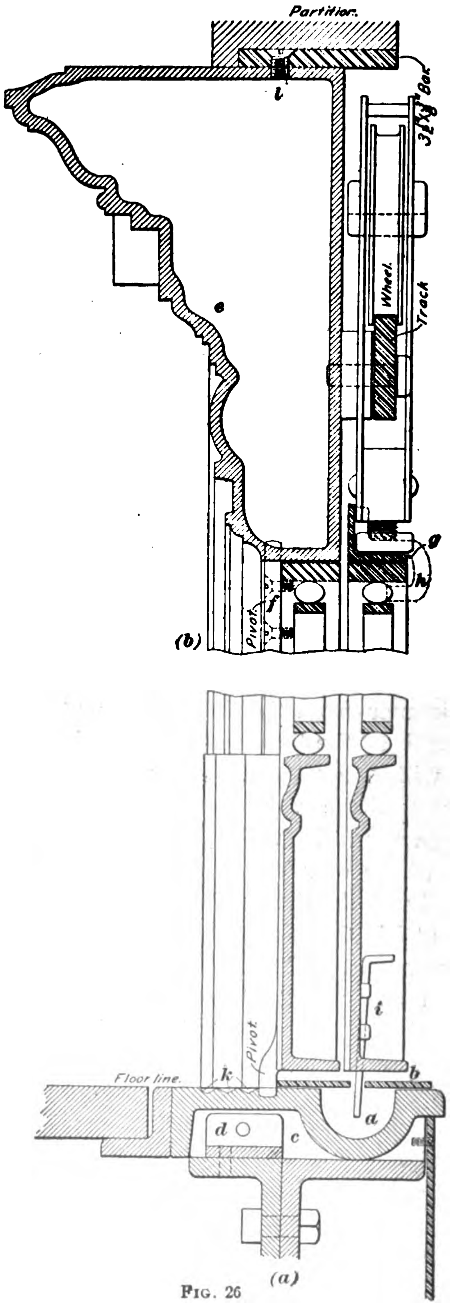

Partition
i
3½"×⅜" Box
Wheel
Track
e
g
h
f
Pivot
(b)
Pivot
i
Floor line
k
b
a
d
c
(a)

FIG. 26

the jamb, as shown at (*d*); or, the top of the jamb may be cast with a flange, or lug, about ½ inch down from the top, as shown at (*e*). The ½-inch clearance permits the jamb to be shortened a trifle if necessary, when fitted to its position.

The jambs being set perfectly plumb, the sill *f* is then put down, and, as will be seen in the section (*c*), the edge next to the floor is turned down about 1½ inches, to form a flat surface for the flooring to finish against. The angular grooves shown at *k* in the large detail of the sill, Fig. 26(*a*), give a better foothold than if the surface were smooth; the deep groove *a* in the same detail is for the bottom guide of the sliding door to travel in, and is made ample in width, and closed in on each side with a strip of wrought iron *b*, to permit of adjustment in case the cast sill is not set exactly true. The wrought-iron plates are also advantageous, inasmuch as they serve better to keep the door in its proper place and reduce the friction surface to the narrow edges of the strips only. As the side of the sill next to the shaft is not deep enough to reach to the beam, upright ribs *c* are cast about 3 feet apart along the under side; and on one side of each of these ribs is riveted a piece of angle iron *d*, which is bolted to the beam. The cornice is a hollow casting, as shown in Fig. 26 (*b*). It is open at the ends where the extensions of the side jambs pass behind it, and it is mitered with the architrave at the corners where it joins and is bolted to the jambs and architrave with countersunk screw bolts. The cornice is fastened to a bar with screw bolts, as shown at *l*, and the bar in turn is bolted at each end to the jambs.

10. In Fig. 27 is shown a plan and horizontal section of the front of the enclosure. The strap brackets *a* are of 2″ × 2″ angle iron, and are so placed as to brace the opening laterally. They are bolted to the structural column with expansion bolts, and to the architrave with countersunk screw bolts. The webs *b* of the architrave are thick enough to provide a firm and sufficient hold for the tap or screw bolts securing the door stop. These stops are fitted with a rubber cushion *c*, which takes up the recoil and noise of the door when operated.

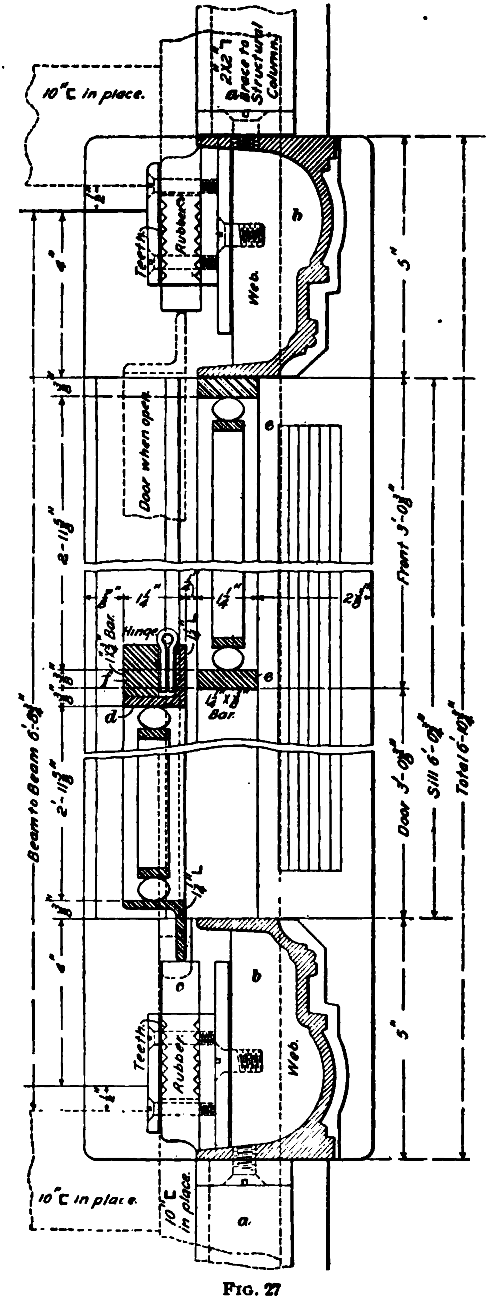

10" ⊏ in place.
2"×2" ⌐ Brace to Structural Column.
a
b
Teeth
Rubber
Web.
Door when open
e
Hinge
1½" Bar.
1¼"
¼"
2⅞"
d
1¼"×⅜" Bar.
1¼" L
c
Beam to Beam 6'-0¾"
2'-11⅝"
4"
⅜"
½"
5"
Front 3'-0⅜"
Door 3'-0⅜"
Sill 6'-0¾"
Total 6'-10¾"
10" ⊏ in place.

FIG. 27

By referring to the elevation, Fig. 25 (*b*), it will be observed that the grille-work is divided into two large panels, one being the door *g*, and the other a pivoted panel *h*. The frame of the door is composed of angle irons, as shown at *d*, Fig. 27, and the frame of the pivoted panel, of flat bars, as shown at *e*. The pivots are fastened to these bars with screw bolts, as shown at *f* in Fig. 26 (*b*). On the sliding door is a bar shown at *f*, Fig. 27, to which the door is hinged. This bar carries at the bottom a guide, which fits in the groove of the track, and is secured at the top to the angle iron *g*, Fig. 26 (*b*), which is a slight extension of the door frame. The door is held in place by the guide bolt *i*, Fig. 26 (*a*), and the panel, by sliding bolts. The reason for this arrangement is to facilitate and make possible the entrance to the elevator of large pieces of furniture; in such a case, the whole front may be swung open by first drawing the sliding bolts in the pivoted panel, then drawing the guide bolts and pushing back the sliding door to its full extent. Both sections are then swung open, the bar and the angle iron remaining attached to the hinges. When used under ordinary conditions, the sliding door is held in place and firmly attached to the hanger by the clips shown dotted at *h*, Fig. 26 (*b*).

11. The hanger consists primarily of a pair of wheels running on a track, from which the door is suspended. These wheels are alike and are set about 12 inches from each end of the door, the position varying somewhat in different doors. Fig. 28 shows the principal features of this hanger, which is patented. The track *a* shown in the section (*b*), on which the wheels run, is fixed to the back of the cornice at each end by cast-iron supporters *b*, Fig. 29, which should be set perfectly level. The track, with the wheels on it, is then put in position, and the bolts *b′* are loosely screwed through the slotted holes in the end. If it is found necessary to further adjust the track, the screws *c* are for that purpose, so that it can be easily set level; then the bolts *b′* are to be screwed up tight. On the arrangement

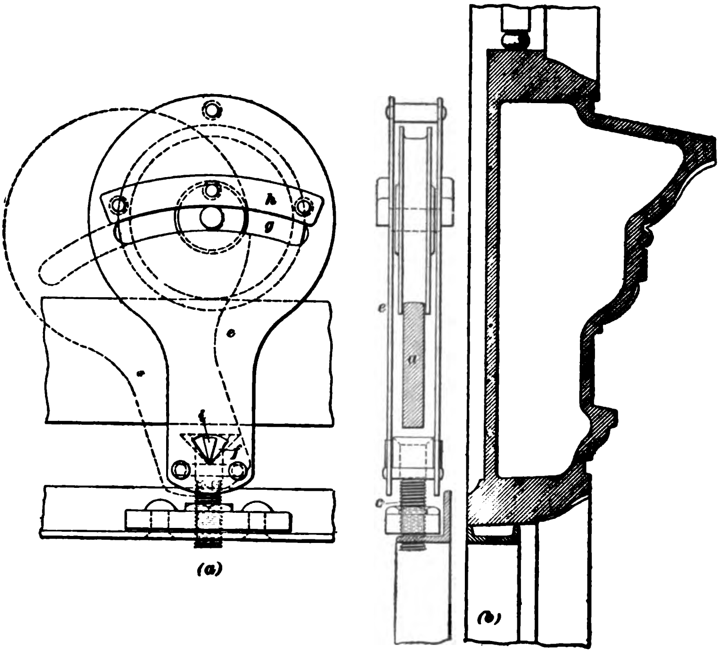


FIG. 28

Note:
After Leveling Track with Adjusting Screw b' tighten Bolt to its limit.

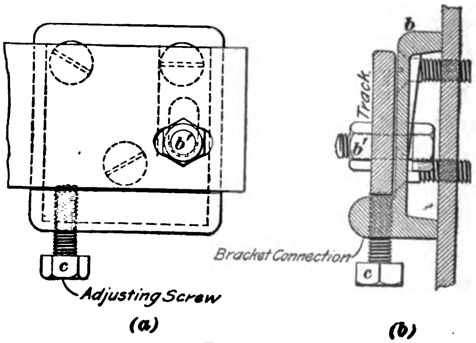


FIG. 29

of the sides that enclose the wheels depends the easy gliding motion. These sides *e*, Fig. 28, are punched out of solid steel. At the lower end, there is a **V**-shaped hole *f* and across the center is a slot *g* reinforced by a steel strap *h* in which the axle of the wheel travels and revolves, as shown in Fig. 28 (*a*). The slot is an arc of a circle whose center is the lower angle of the **V**-shaped hole, and the door is suspended from the knife-edge bearings *i* resting in this **V**. When the door is at rest, the wheel is in the position shown by the full lines, and as it is pushed along, the sheaves gradually swing over to the position shown by the dotted lines, the center of the wheel always remaining over the point of suspension. This prevents any rubbing motion at any point, as the axle of the wheel is not bound in any way, but simply rolls in the slot, and it is evident that the friction at the point from which the door hangs is practically nothing. If it is found necessary to raise or lower the door itself, this may be done, after everything is in position, by turning the suspending bolts *c*, which are squared at the neck to afford a hold for a key or wrench.

12. The construction of the enclosure, as well as the design shown in Fig. 30, differs considerably from that of the preceding example. With the exception of three details, it is entirely of wrought iron, these exceptions being the sill, the transom, and the molding at the top of the lower panels. By referring to the plan (*a*) and elevation (*b*) of the small scale detail, Fig. 31, also the section (*d*), the surroundings governing the design may readily be seen. The main support of the screen is a round bar or column, shown at *a*, Fig. 30, which consists of a 2½-inch wrought-iron pipe fitted with a cap and base. The top is secured to the soffit of the brick arch over the partition with an expansion bolt, and also to the cast-iron sill at the floor level. The grille screen is separated from this column by a small post *b*, which forms the sides of the grille frame and is finished with base and finial. It is fastened to the main column *b* by collar straps *c* on the lower part, and by the transom extension *d*

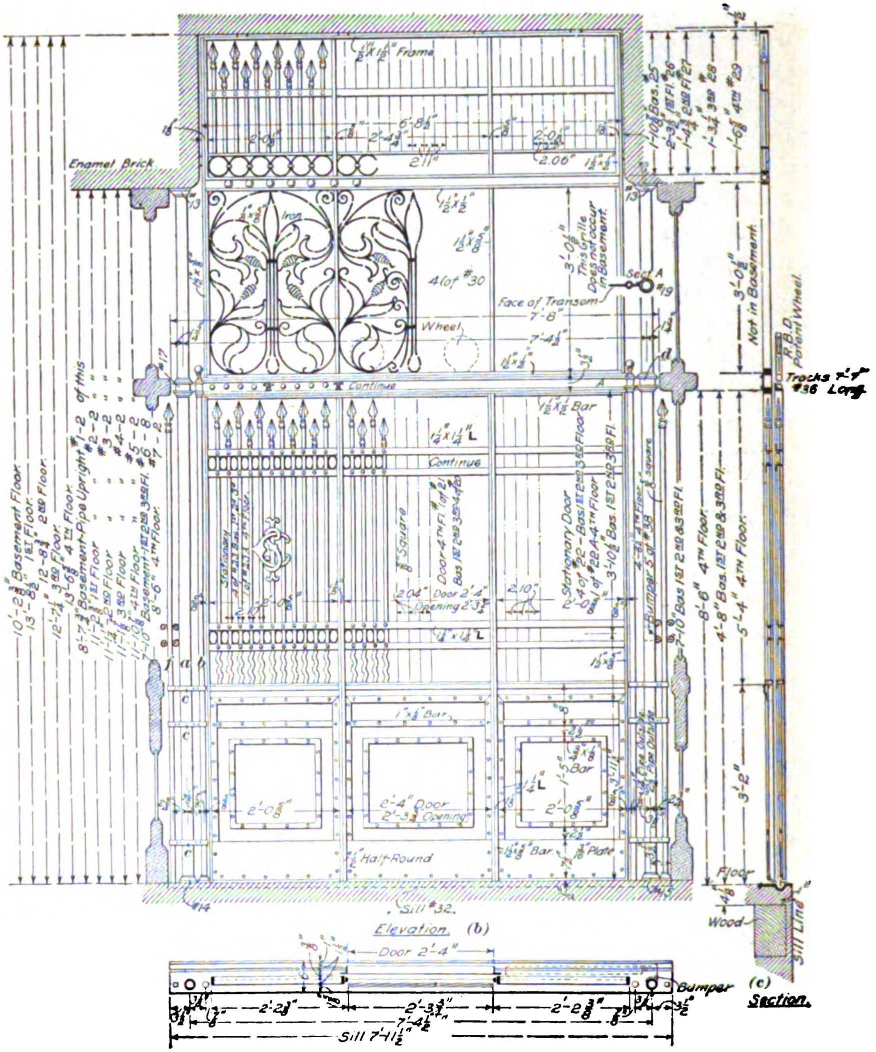

Enamel Brick
$1\frac{1}{2}$"x$1\frac{1}{2}$" Frame
6'-8$\frac{1}{2}$"
2'-0$\frac{5}{8}$"
2'-4$\frac{3}{4}$"
2'-0$\frac{5}{8}$"
2'11"
2.06"
Iron
$1\frac{1}{2}$"x$\frac{1}{2}$"
4 (of #30
3'-0$\frac{1}{2}$"
This Grille Does not occur in Basement.
Sect. A
#19
Face of Transom
7'-8"
7'-4$\frac{1}{2}$"
Wheel
Continue
$1\frac{1}{2}$"x$\frac{1}{2}$" Bar
$1\frac{1}{4}$"x$1\frac{1}{4}$" L
Continue
$\frac{5}{8}$" Square
Door 4TH Fl. #1 of 21
2.04" Door 2'-4"
Opening 2'-3$\frac{1}{2}$"
2.10"
Stationary Door
2'-0$\frac{5}{8}$"
3'-10$\frac{1}{2}$" Bas. 1ST 2ND 3RD Fl.
Bumper 5 of #38
$1\frac{1}{4}$"x$1\frac{1}{4}$" L
1"x$\frac{1}{4}$" Bar
2'-0$\frac{5}{8}$"
2'-4" Door
2'-3$\frac{1}{2}$" Opening
2'-0$\frac{5}{8}$"
1'-5"
$\frac{1}{2}$" Half-Round
Bar
Plate
Sill #32.
#14
#13
#17
10'-2$\frac{3}{4}$" Basement Floor.
13'-8$\frac{1}{4}$" 1ST Floor.
12'-8$\frac{3}{4}$" 2ND Floor.
12'-7$\frac{1}{4}$" 3RD Floor.
13'-6$\frac{3}{4}$" 4TH Floor.
8'-7$\frac{3}{4}$" Basement-Pipe Upright #1-2 of this
11'-2" 1ST Floor #2-2
11'-1" 2ND Floor #3-2
11'-1$\frac{1}{2}$" 3RD Floor #4-2
11'-10$\frac{1}{4}$" 4TH Floor #5-2
7'-10$\frac{1}{2}$" Basement-1ST 2ND 3RD Fl. #6-8
8'-6" 4TH Floor. #7-2
1'-10$\frac{1}{2}$" Bas. #25
2'-3$\frac{3}{4}$" 1ST Fl. #26
1'-4$\frac{3}{4}$" 2ND Fl. #27
1'-3$\frac{1}{4}$" 3RD #28
1'-6$\frac{3}{4}$" 4TH #29
3'-0$\frac{1}{2}$"
Not in Basement.
R.B.D. Patent Wheel.
Tracks 7'-7" #36 Long
7'-10" Bas. 1ST 2ND & 3RD Fl.
8'-6" 4TH Floor.
4'-8" Bas. 1ST 2ND & 3RD Fl.
5'-4" 4TH Floor.
3'-2"
Floor
Wood
Sill Line
Elevation. (b)
Section. (c)
Door 2'-4"
Bumper
2'-2$\frac{3}{8}$"
2'-3$\frac{3}{4}$"
2'-2$\frac{3}{8}$"
7'-4$\frac{1}{2}$"
Sill 7'-11$\frac{1}{2}$"
Horizontal Section. (a)

FIG. 30

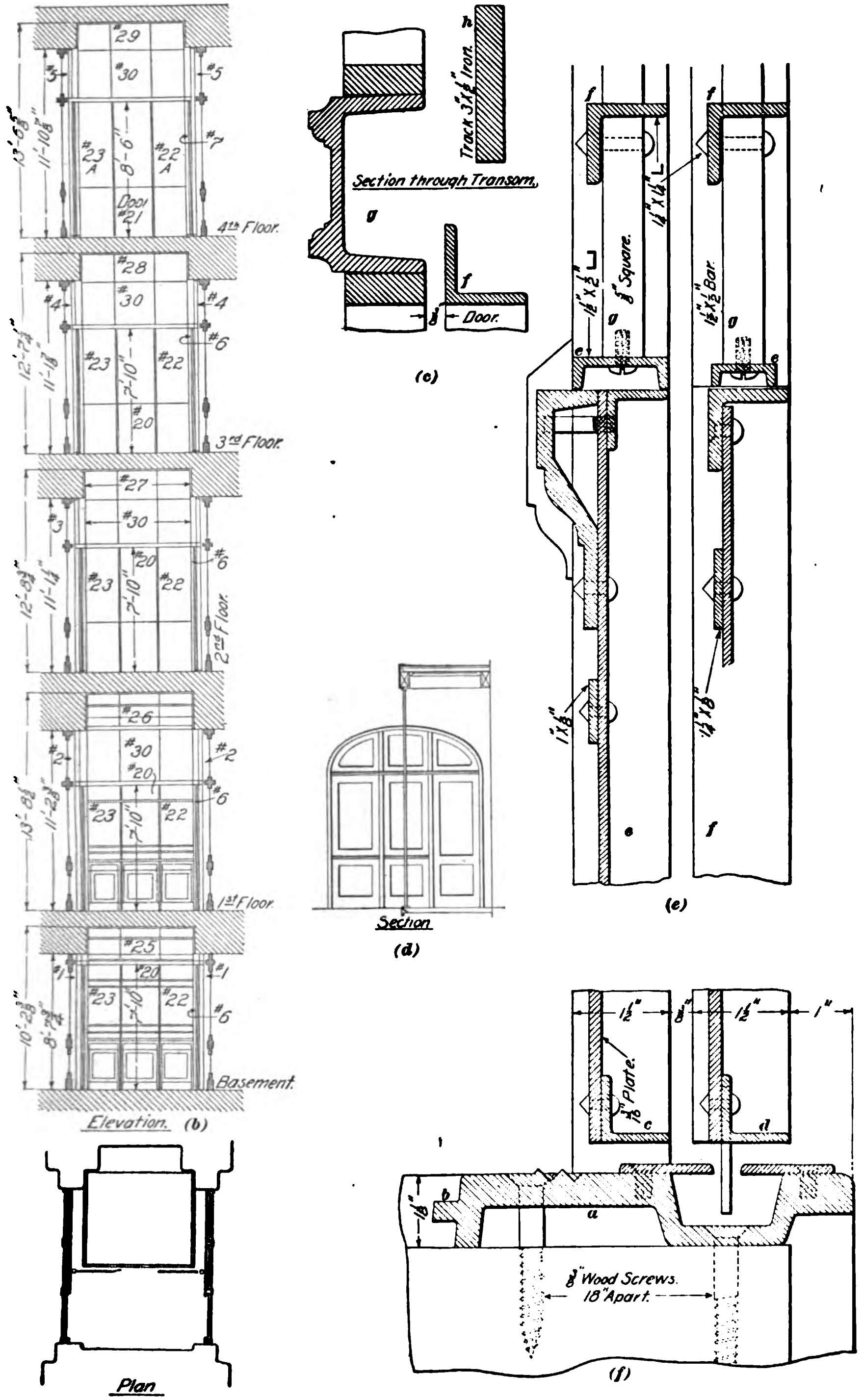

#29
#30
#5
13'-6 5/8"
11'-10 7/8"
#23 A
8'-6"
#22 A
#7
Door #21
4th Floor.
#28
#30
#4
12'-7 1/2"
11'-1 8"
#23
7'-10"
#22
#6
#20
3rd Floor.
#27
#30
#3
12'-8 1/2"
11'-1 1/2"
#20
#23
7'-10"
#22
#6
2nd Floor.
#26
#30
#2
13'-8 1/2"
11'-2 3/8"
#20
#23
7'-10"
#22
#6
1st Floor.
#25
#20
#1
10'-2 3/8"
8'-7 3/4"
#23
7'-10"
#22
#6
Basement.
Elevation. (b)
Plan
(a)
h
Track 3"X 5/8" Iron.
Section through Transom.
g
f
1/8"
Door.
(c)
Section
(d)
f
1 1/4" X 1 1/4" L
1 1/2" X 1/2" L
5/8" Square.
1 1/2" X 1/2" Bar.
g
e
1" X 1/8"
1 1/4" X 1/8"
e
f
(e)
1 1/2"
3/8"
1 1/2"
1"
3/16" Plate.
c
d
1 1/8"
b
a
3/8" Wood Screws.
18" Apart.
(f)

FIG. 31

at the top. The jambs of the door opening are formed of half rounds, to correspond to the post *b* and to strengthen the center of the screen. The space between the post and the partition is fitted with a small bar *f* to fill the space between the column *a* and the side walls. The sill shown in detail in Fig. 31 (*f*) has a tongue *b* cast on it to receive the finished floor, which is grooved to fit over this tongue and thereby make a snug and unyielding joint. The stationary panels of the screen each side of the door have a dado panel in plate iron, and grille-work above; the same treatment being used in the door.

13. A section of the screen, Fig. 30 (*c*), shows the sliding door on the inside of the shaft and the hanger above. Fig. 31 (*f*) shows a section through the cast-iron sill and the method of screwing it to the wooden under floor. At *d* is a section of the bottom of the sliding door, while at *c* is the fixed panel. The sections of the upper moldings on the dado panel of the door and screen are shown in Fig. 31 (*e*); and at *g* is seen the elevation of the lower part of the bars of the grille, and the screw that secures each of them to the channel iron forming the surrounding and protecting frame. In Fig. 31 (*c*), a section of the transom bar is shown at *g*, a section of the top of the door at *f*, and the track on which it slides at *h*. The enclosure on each story being similar in design, it is not necessary to detail each one. A general plan and elevation is given in Fig. 31 (*a*) and (*b*), and one detail plan and elevation in Fig. 30, on which the varying dimensions of all the stories are marked. Each piece is numbered, and the quantity is also noted on these drawings. In all cases, the drawings are accompanied by a list or schedule.

14. The general construction of all elevator enclosures is practically the same as the examples given in the preceding articles and further details are unnecessary. In the enclosure screen shown in Fig. 32, the architrave is of cast iron, the general outlines and form of which are designed to correspond with the adjoining trim. This architrave is

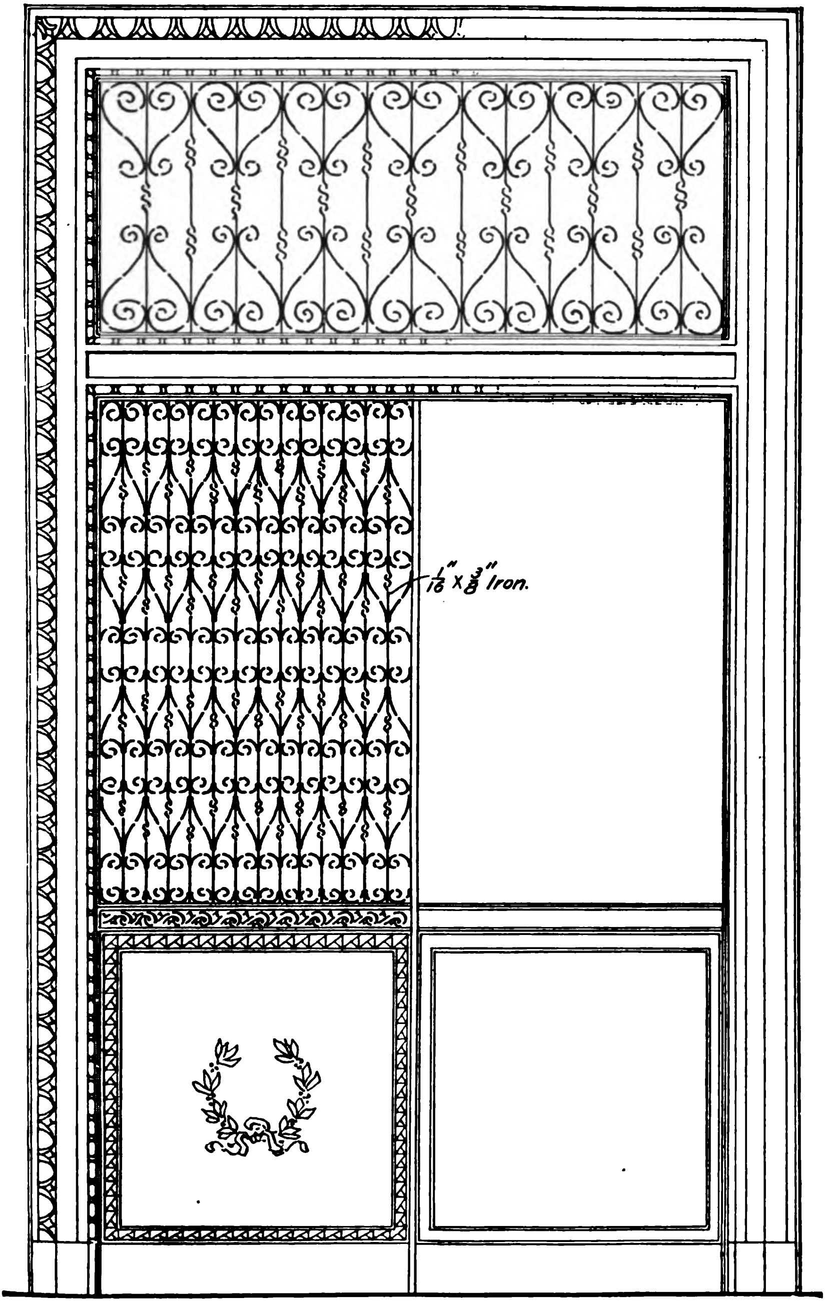


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FIG. 32

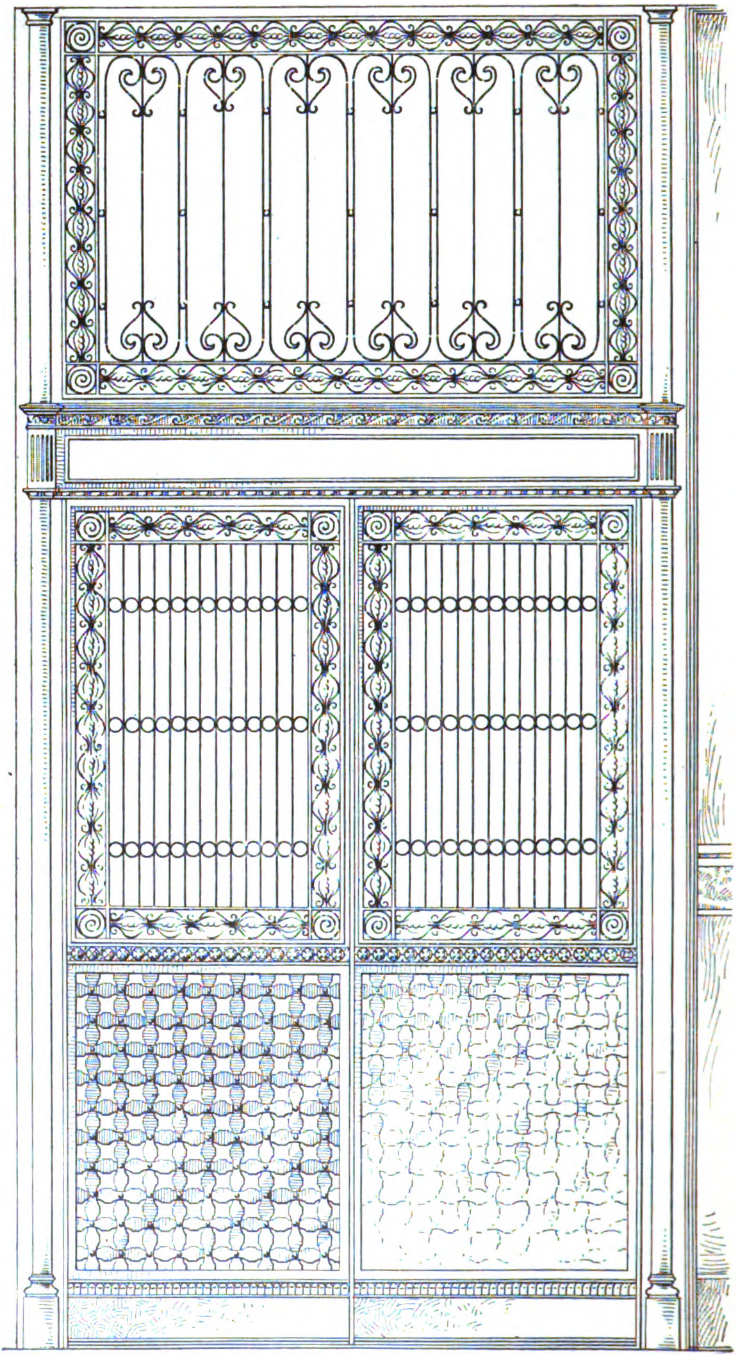


FIG. 33

decorated on the jamb side with a spool-and-spindle fillet mold, and on the outer edge with an egg-and-dart echinus molding. The dado panel is of sheet iron surrounded with a tooth molding, and the center is decorated with a wreath of myrtle leaves, berries, and ribbon in wrought or cast iron. The grille of the door is much closer than the transom grille, thus giving a heavier and close effect in the proper place. Both these grilles are formed from $\frac{1}{16}''$ × $\frac{3}{8}''$ strap iron set with the edge to the front, the very open portions being relieved by twisting the bars so as to produce a spiral, showing the full width of the bar to the front.

15. In Fig. 33, the whole screen is formed of wrought iron, except the transom bar. This design presents several very agreeable and pleasing features; it is well balanced, and the transition, which should always be studied in design, from the heavy effect in the dado to the light area in the transom, is here well defined. The dado is especially good, as it combines protection, good design, and cheapness. The pattern, which is a diaper, is made of the usual basket strap work with the edges cut to the form shown. The rail is not too heavy, and shows a molding with a rosette-and-leaf decoration. The filling of the panel is of a series of bars well braced and bound together with three rows of rings. The transom bar—the only piece of cast iron—is finished at the ends with fluted and molded collar bands, through which the columns supporting the screen pass. The transom grille border is a repetition of the door grille, and the center is composed of six very open panels, separated by small button washers, thus completing the screen.

16. Fig. 34 is given as a fine example of wrought iron and cast iron combined. The large pilasters break the long stretch of grille-work into bays, at the same time serving to cover and decorate the plain structural-steel columns that are hidden behind them.

17. Ornamental iron elevator enclosures are sometimes combined with other materials, such as marble. Fig. 35 is a good specimen of this treatment. The white squares seen

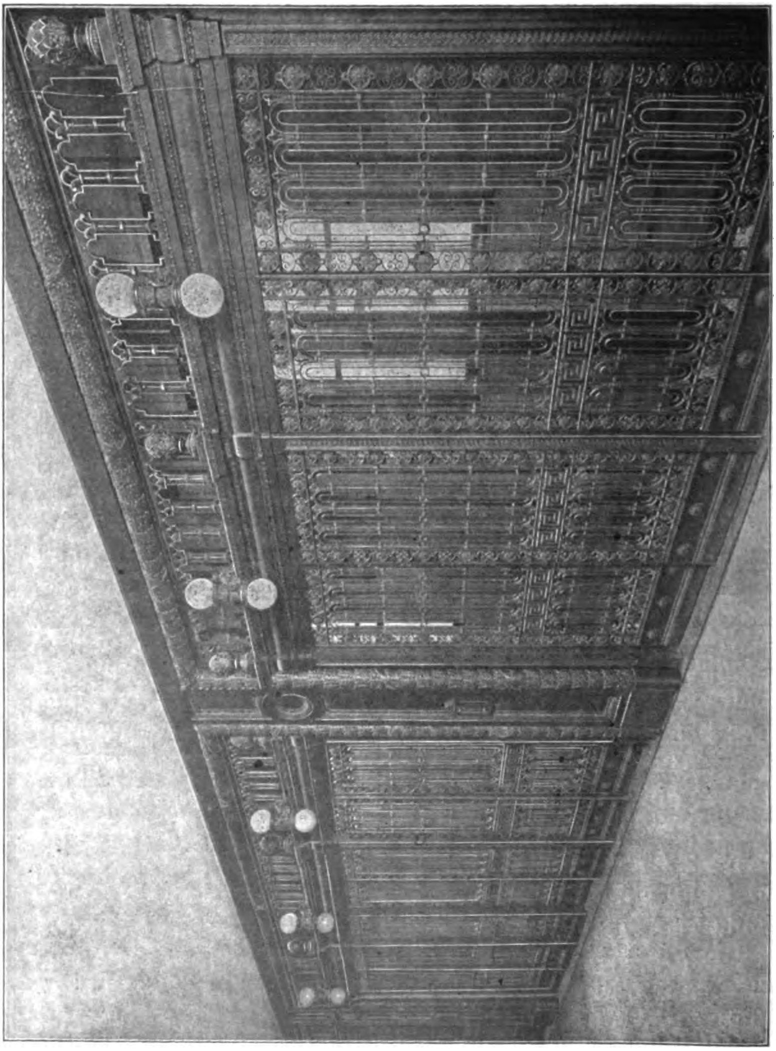


FIG. 34

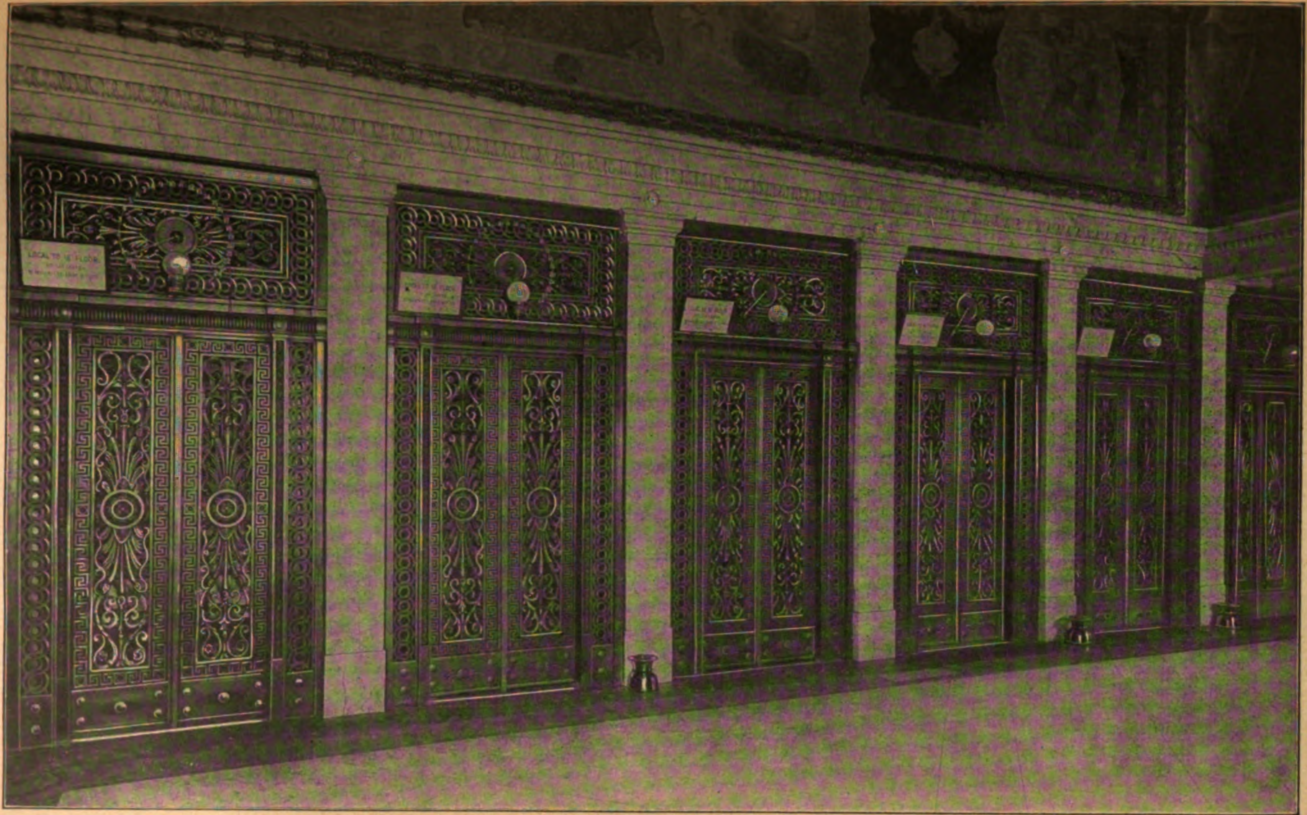


FIG. 35

)

over the doors are merely notice boards placed there for the direction of the public. When it is known in advance that

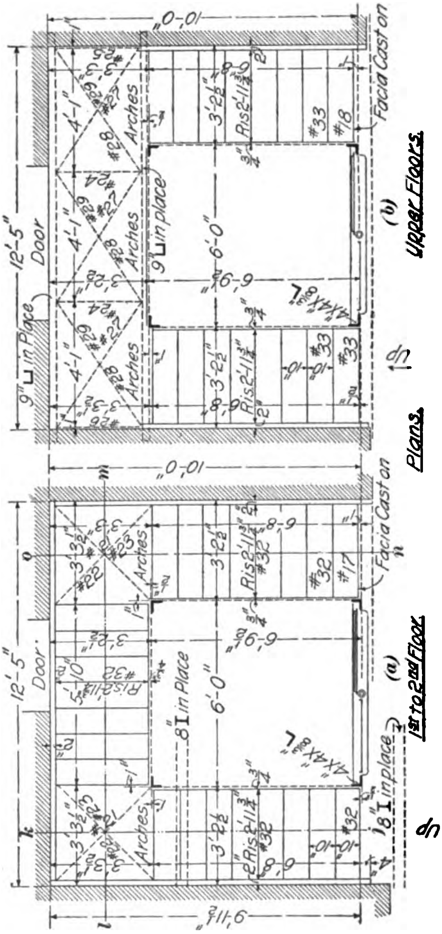


FIG. 38

such notices are likely to be needed, it is better to form a suitable place for them in designing the transom grille.

COMBINED ELEVATOR AND STAIR SHAFTS

18. In fireproof buildings, it is a common practice to combine the elevators and stairs in one shaft. In such cases, the elevator usually occupies the center of the shaft, and the stairway is constructed around it. Such a combination is shown in plan in Fig. 36, where the arrangement of stairs and elevator shaft on the first floor is shown at (*a*), and on the upper floors at (*b*). A 6′ × 6′ 9½″ elevator shaft is thus provided, around three sides of which rises a stairway 3 feet 2½ inches in the clear. So far as the details of the stairs are concerned, they are precisely the same in principle as those described in *Ornamental Metal Work*, Part 1; the wall strings are first set in place, then the face strings (which in this case are the well strings), and finally the risers and treads. The well strings, however, have to be considered with the elevator shaft, as they form a part of that structure; and the details of the grille-work screen around the elevator shaft should include a treatment that will take the place of a balustrade on that side of the stairs.

The elevations of the wall strings, the outside strings, and the sides and back of the enclosure, also the front elevation of the enclosure, are shown in Fig. 37 (*a*), (*b*), (*c*), and (*d*). The grille-work on the first story is of brass, and on the stories above, of iron.

19. As in the previous examples of stair work, the first procedure is to fix the number of risers and the width of the stairs. The height, as shown in Fig. 37 (*a*), is 14 feet 8¼ inches between the first and second stories; and to determine the number of risers, the size of the well hole, as well as the approximate space that the elevator will occupy, should be considered, though the latter may be modified to work out the stairs. It will be seen that twenty-six risers each 6.77 inches high, counting from top to top of the treads, gives nine risers each side of the well and eight at the back. This will permit the treads to be 10 inches wide on the sides and back, all finishing nearly symmetrically at the corners. The face of the first riser leading down the stairway, as shown in Fig. 36 (*a*), is ½ inch from the corner of the angle-iron frame of the well, and the ninth riser is 1 inch from the corner of the corresponding angle at the back

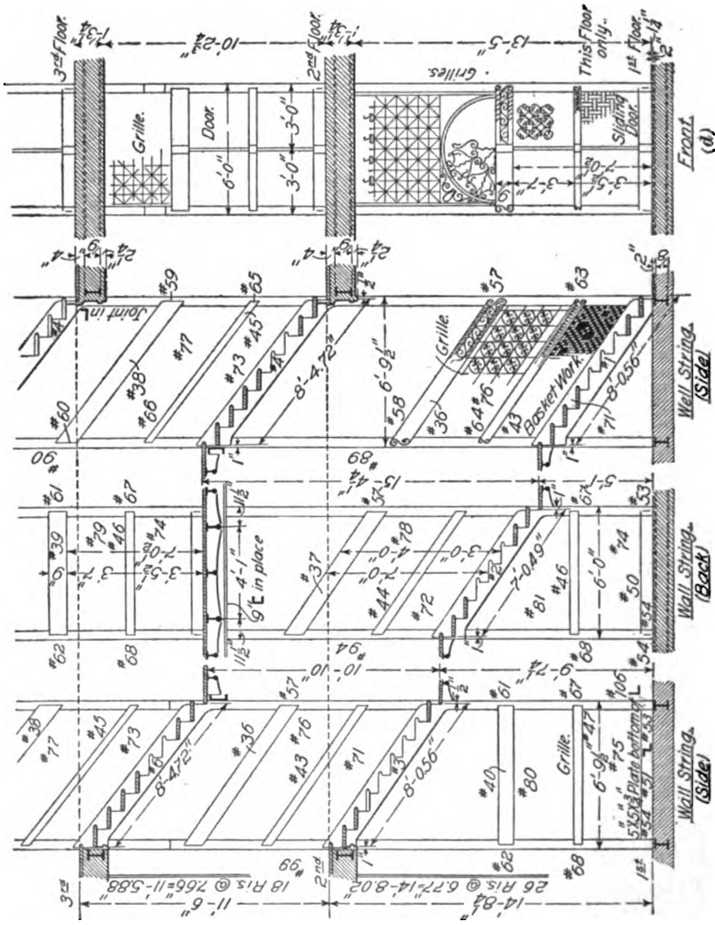


FIG. 37

of the shaft. The upper part of the opposite side is similar, and the run at the back has the tenth and seventeenth risers, each 1 inch back of the angle iron, thus in each case allowing sufficient room for the finished tread to stop inside the edge of the angle. In planning any stair that is broken by intermediate platforms, the starting riser of each section should, if possible, be kept the same distance from a fixed point; in this example, these points are represented by the angles at the corners of the well. Circumstances may arise, as in the present case, when this arrangement is not possible, and then the space is divided as equally as possible.

The upper stories being less in height than the first story, fewer risers are required; and, by making them 7.66 inches high, the plan of the stair on each side of the well remains the same as the first story, while at the back the platform extends across the full width of the well. In fact, the stairs in every case should be planned as a whole, and not simply flight by flight.

20. The plans being determined, the wall and outside, or well, strings, and the sides and back of the enclosure should be laid out on the section lines *j k*, *l m*, and *n o*, shown in Fig. 36 (*a*), the developments of which are shown in Fig. 37 (*a*), (*b*), (*c*), and (*d*), and in Fig. 38 (*a*), (*b*), and (*c*). The elevation of the front is also shown in Fig. 37 (*d*). In most stairs, the platforms are of slate or marble, and must be supported at the center or diagonally by either cast- or wrought-iron ribs or arches, as indicated by the dotted lines shown on the plans, Fig. 36. The development and details of the parts of the enclosures and stairs are shown in Fig. 39; (*a*) shows the head of the outside string in sectional elevation and plan at the first platform, between the first and second stories; (*b*), the foot of the outside string in sectional elevation and plan at the first platform, between the first and second stories; (*c*), the wall string in sectional elevation and plan at the first platform, between the first and second stories, and an elevation of the arch rib supporting the platform and the springing block to which the rib is bolted. At (*d*) is shown the sectional elevation and plan of the head and foot of the outside string, with the enclosure of basketwork and grille as they exist in the upper stories, and (*e*) shows the sectional elevation and plan of the wall string of the same run. At (*f*) is shown a sectional elevation and plan of the head and foot of the outside string on all the platforms and landings of the upper stories. At (*g*) is shown the wall string and the platforms and landings of the same run. In

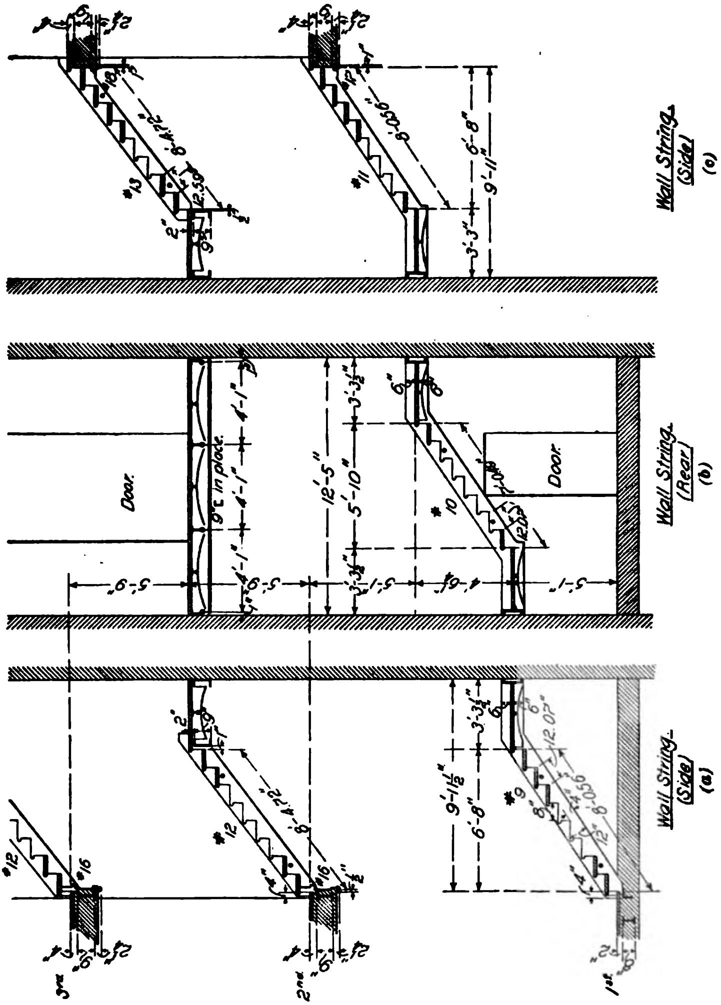
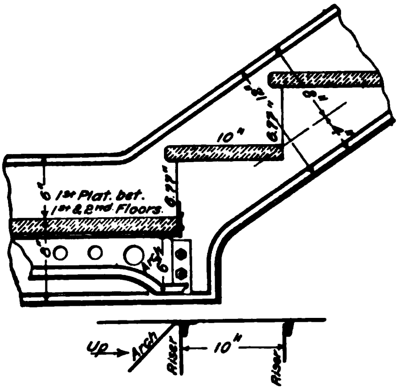
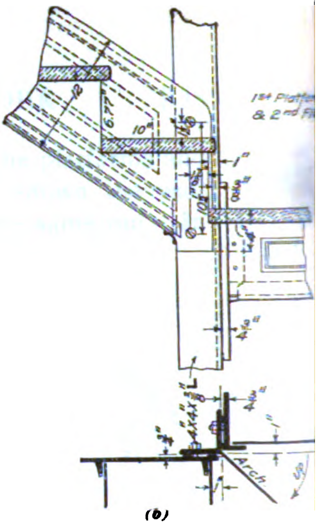


FIG. 38

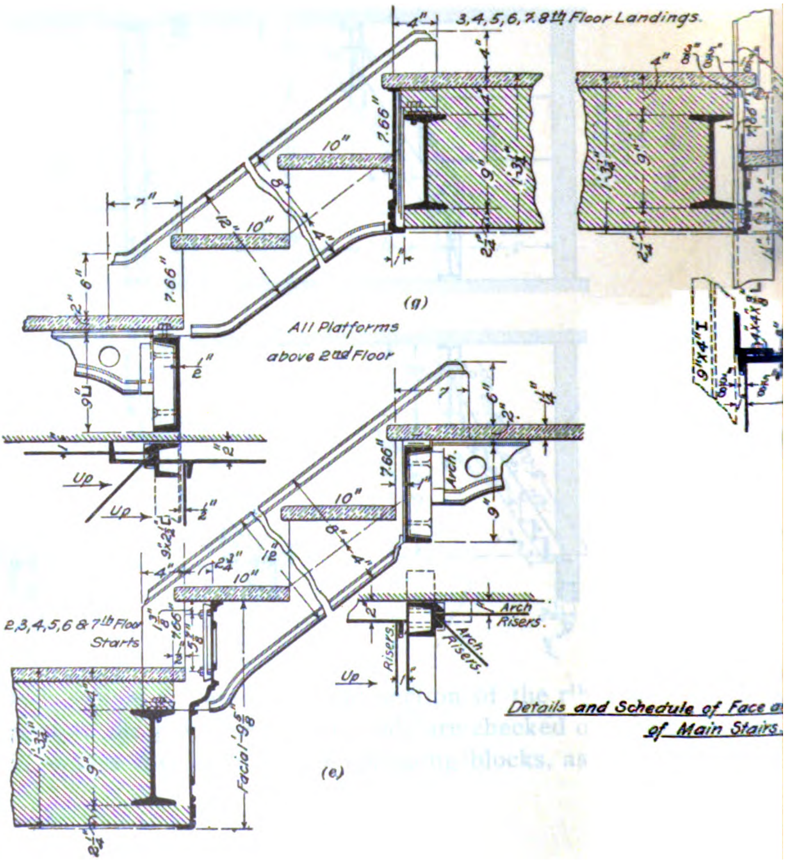
Fig. 40 is shown the elevation and section of the rib arches that support the platforms. The ends are checked out $\frac{3}{4}$ in. × 1 in., where they rest on the springing blocks, as shown.



(c)



(b)

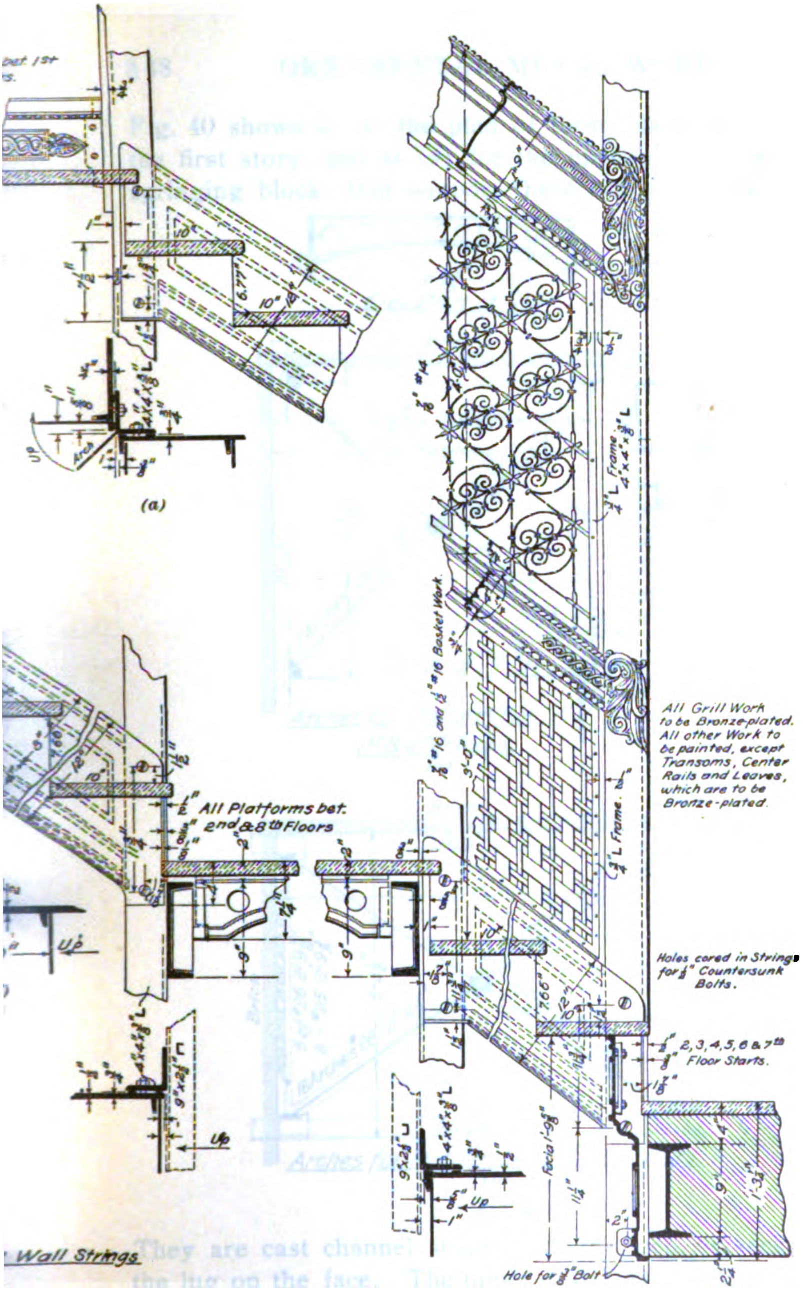


(g)

(e)

Details and Schedule of Face a
of Main Stairs.

Fi



Wall Strings

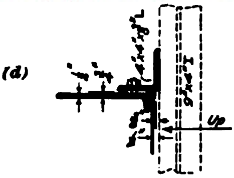
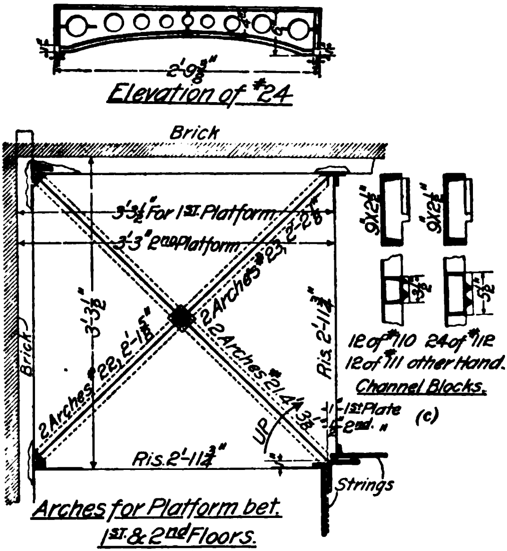
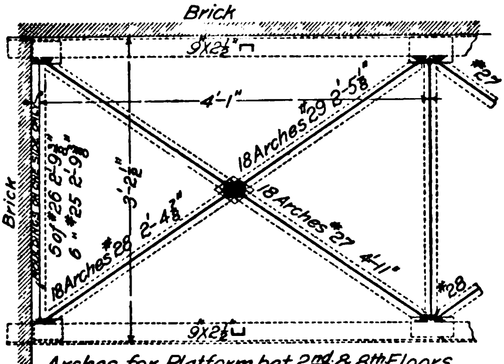


Fig. 40 shows at (*a*) the plan of these platform arches for the first story, and at (*b*) for the upper stories, while the springing blocks that support these ribs are shown at (*c*).



Arches for Platform bet. 1st & 2nd Floors.
(a)



Arches for Platform bet. 2nd & 8th Floors.
(b)

Fig. 40

They are cast channel shape, with the web, or socket, and the lug on the face. The upper drawings at (*c*) show these blocks in elevation, the lower drawings in section.

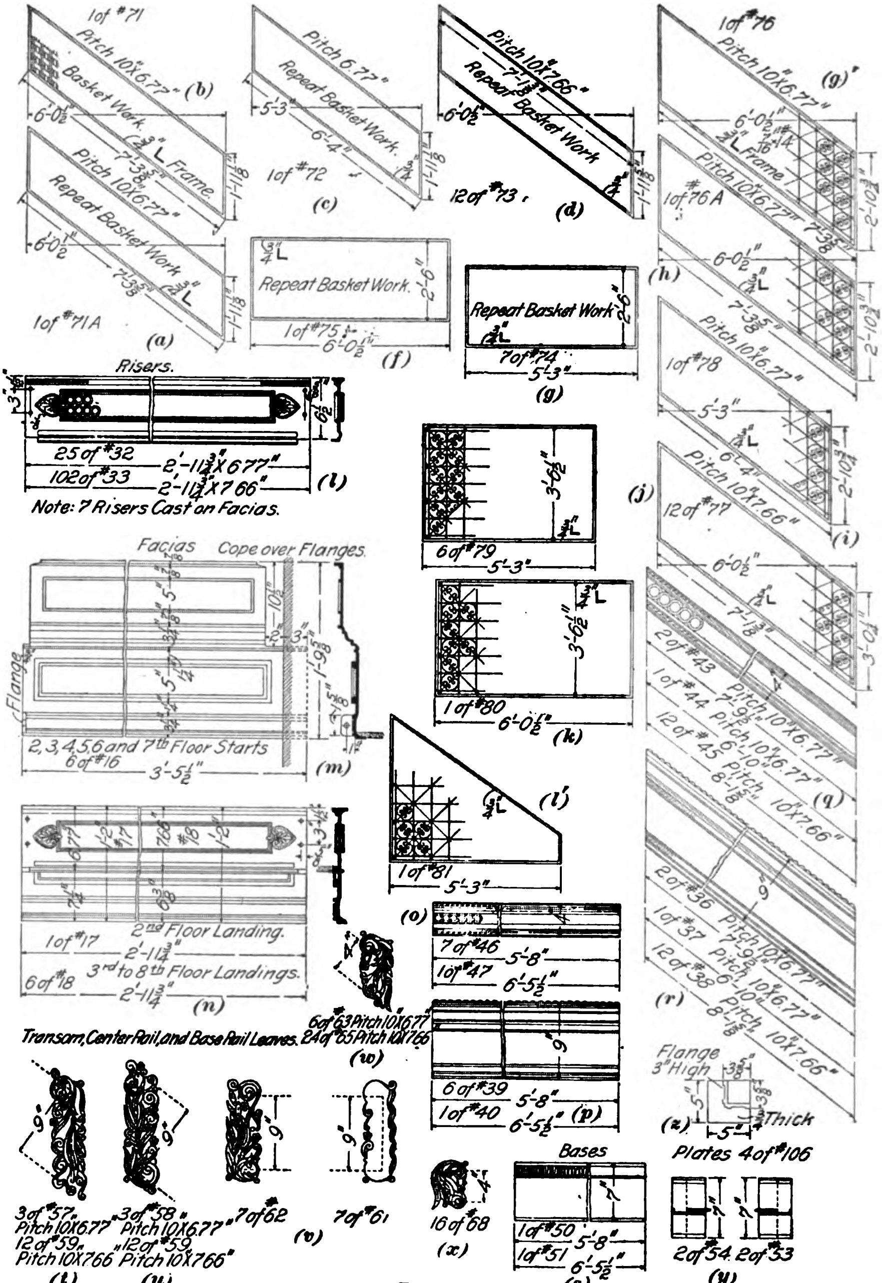

1 of #71
Pitch 10"X6.77"
Basket Work.
(b)
6'-0½"
¾" L Frame.
7'-3⅝"
1'-1⅛"
Pitch 10"X6.77"
Repeat Basket Work
6'-0½"
7'-3⅝"
¾" L
1'-1⅛"
1 of #71 A
(a)
Pitch 6.77"
Repeat Basket Work.
5'-3"
6'-4"
1'-1⅛"
1 of #72
(c)
Pitch 10"X7.66"
7'-1⅛"
Repeat Basket Work
6'-0½"
1'-1⅛"
12 of #73
(d)
1 of #76
Pitch 10"X6.77"
(g')
6'-0½"
¾" L Frame
2'-10¾"
1 of #76 A
Pitch 10"X6.77"
7'-3⅝"
(h)
6'-0½"
¾" L
7'-3⅝"
Pitch 10"X6.77"
2'-10¾"
1 of #78
5'-3"
¾" L
6'-4"
Pitch 10"X7.66"
2'-10¼"
12 of #77
(i)
6'-0½"
¾" L
7'-1⅛"
3'-0¼"
¾" L
Repeat Basket Work.
2'-6"
1 of #75
6'-0½"
(f)
Repeat Basket Work
2'-6"
¾" L
7 of #74
5'-3"
(g)
Risers.
3"
6½"
25 of #32
2'-11¾"X6.77"
102 of #33
2'-11¾"X7.66"
(l)
Note: 7 Risers Cast on Facias.
6 of #79
3'-6½"
¾" L
5'-3"
(j)
3'-6½"
¾" L
1 of #80
6'-0½"
(k)
Facias
Cope over Flanges.
Flange
10½"
2'-3"
1'-9⅝"
2, 3, 4, 5, 6 and 7th Floor Starts
6 of #16
3'-5½"
(m)
2 of #43 Pitch 10"X6.77"
1 of #44 Pitch 10"X6.77"
7'-9⅞"
6'-10"
12 of #45 Pitch 10"X7.66"
8'-1⅝"
(q)
(l')
¾" L
1 of #81
5'-3"
#17
#18
1 of #17
2nd Floor Landing.
2'-11¾"
3rd to 8th Floor Landings.
6 of #18
2'-11¾"
(n)
(o)
7 of #46
5'-8"
1 of #47
6'-5½"
2 of #36 Pitch 10"X6.77"
1 of #37 Pitch 10"X6.77"
7'-9⅞"
6'-10"
12 of #38 Pitch 10"X7.66"
8'-1⅝"
(r)
9"
6 of #63 Pitch 10"X6.77"
24 of #65 Pitch 10"X7.66"
(w)
Transom, Center Rail, and Base Rail Leaves.
9"
6 of #39
5'-8"
1 of #40
6'-5½"
(p)
Flange
3" High
3⅝"
5"
3⅝"
¾" Thick
(z)
5"
9"
9"
9"
9"
3 of #57 Pitch 10"X6.77"
12 of #59 Pitch 10"X7.66"
(t)
3 of #58 Pitch 10"X6.77"
12 of #59 Pitch 10"X7.66"
(u)
7 of #62
(v)
7 of #61
4"
16 of #68
(x)
Bases
7"
1 of #50
5'-8"
1 of #51
6'-5½"
(s)
Plates 4 of #106
7"
7"
2 of 54
2 of #53
(y)

FIG. 41

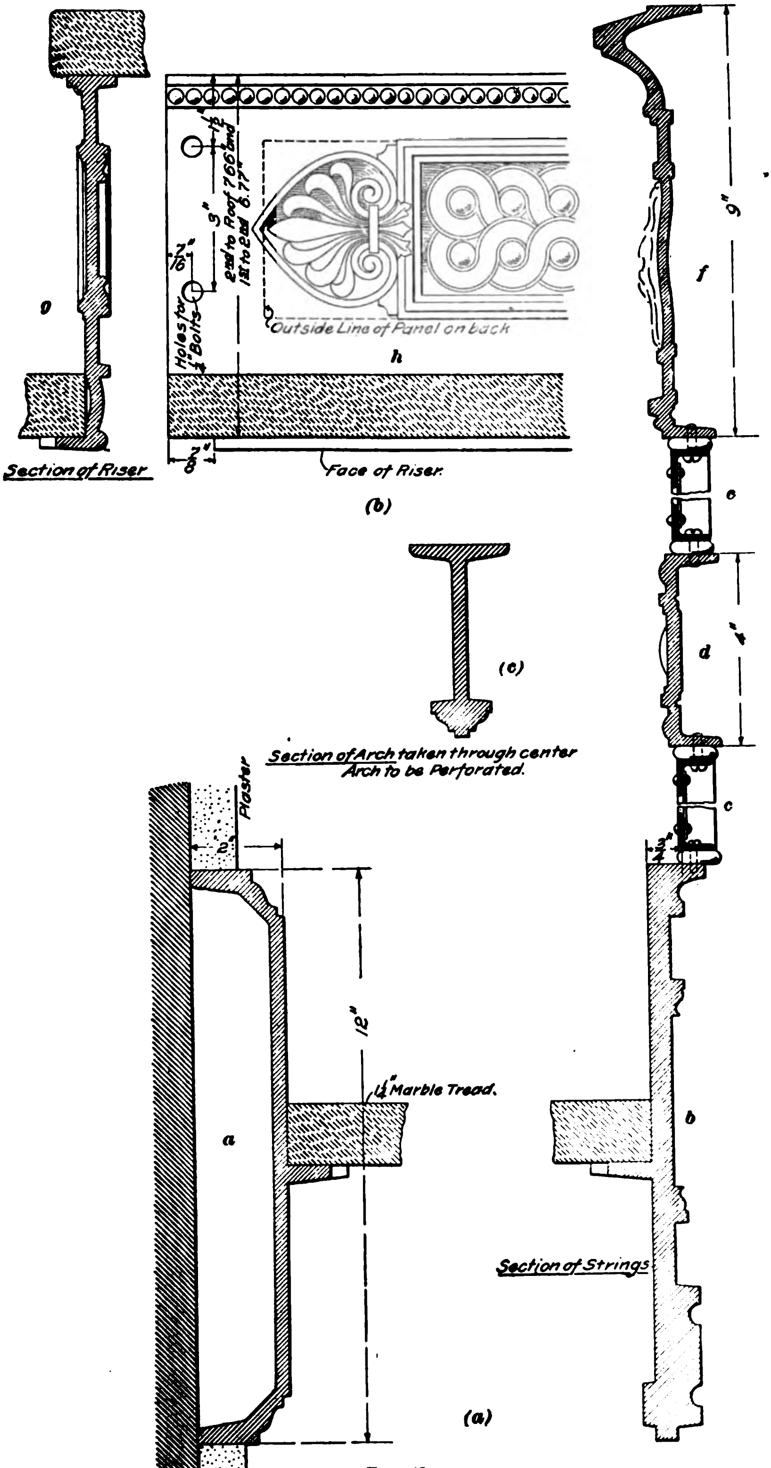
g
Section of Riser
Holes for ¼" Bolts
$\frac{7}{16}$"
$1\frac{3}{8}$"
3"
2nd to Roof 7.66 and
1st to 2nd 6.77"
Outside Line of Panel on back
h
$\frac{7}{8}$"
Face of Riser.
(b)
(c)
Section of Arch taken through center
Arch to be Perforated.
Plaster
2"
12"
$1\frac{1}{4}$" Marble Tread.
a
(a)
9"
f
e
4"
d
c
$\frac{3}{4}$"
b
Section of Strings

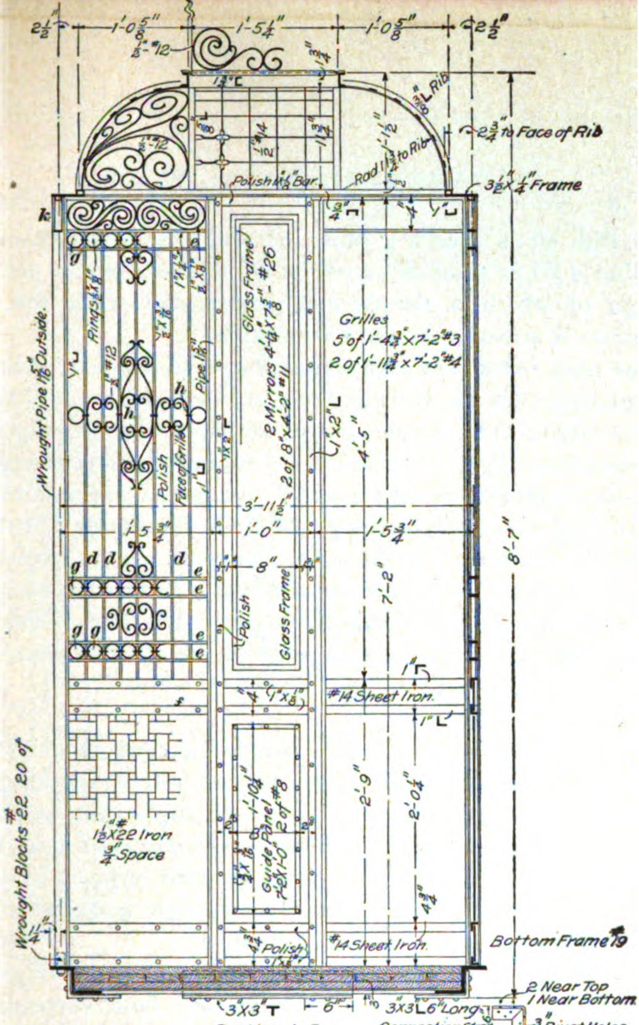
FIG. 42

21. The risers shown in Fig. 41 (*l*) are for all starters on each floor, and for all intermediate risers. The fascias or finish at back of risers underneath stairways shown in Fig. 41 (*m*) are at the start of the upper stories, and form a finish from the first tread (going up) to the plaster of the the ceiling below. See Fig. 39 (*d*). The seven risers cast on the fascias are shown at (*n*), and are for the upper landings, and form a finish from the last tread (going up) to the under side of the plaster. A number of the rails and bases are shown at (*o*), (*p*), (*q*), (*r*), and (*s*); the base (*s*) finishes the enclosure on the first floor only. The center rails (*o*) and (*p*) extend throughout all floors, as do the top rails (*q*) and (*r*). The leaves forming the finish, and covering the joints of the transom, center rail, and base rail, are shown at (*t*). See Fig. 39 (*d*). The finish at the base of the angle irons at the first floor is shown at (*y*) and (*z*), the latter being the plate that is bolted to the I beams to form the foundation of the enclosure, the four angles at the corner being bolted to these plates. The basket grille, which forms the dado of the enclosure, is shown at (*a*), (*b*), (*c*), (*d*), (*f*), and (*g*), and the grille-work at (*g'*), (*h*), (*i*), (*j*), (*k*), and (*l'*).

22. Fig. 42 (*a*) shows the strings, enclosure, arch, and riser in detail. The wall string is shown at *a*, and the well string at *b*; the frame of the basket grille composed of small angle irons is shown at *c*, and the center rail at *d*; the grille frame composed of small angles at *e*, and the top rail at *f*. A section of the riser and an elevation of the front of the same are shown at *g* and *h* in Fig. 42 (*b*); and the arch rib is shown in Fig. 42 (*c*).

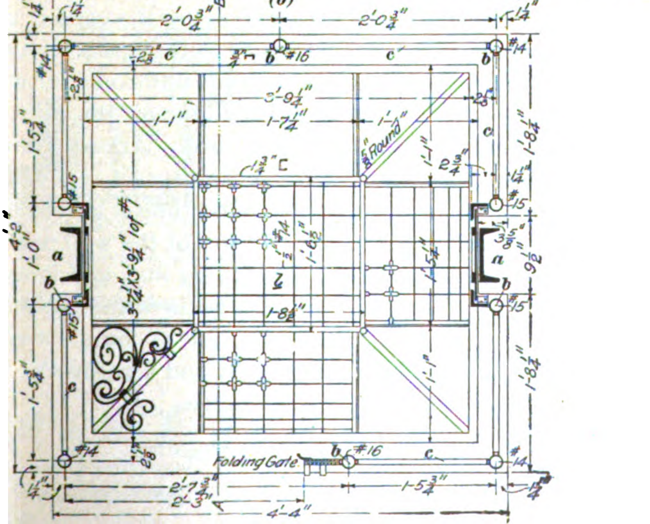
ELEVATOR CARS

23. **Elevator cars** are usually constructed of angle iron or pipe framework, which is filled in with woven basketwork and twisted-iron grille-work and scrollwork. The design of the grille-work is usually similar to, if not identical with, the design of the grille of the enclosure, though sometimes certain conditions require a stronger and less elaborate design in one place than in the other.



Section A-B

(b)



(a)

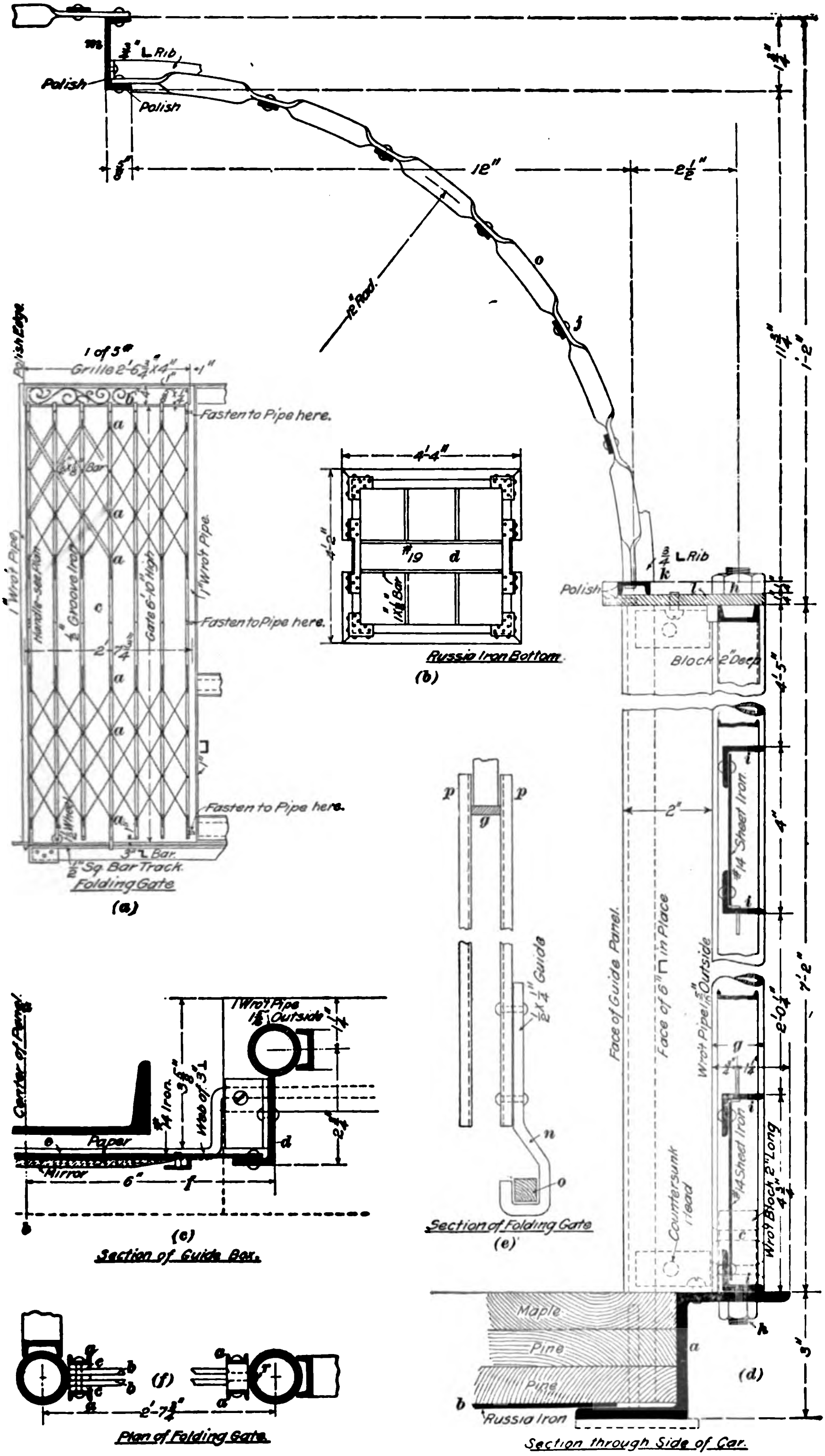
FIG. 48

In Fig. 43 is shown a plan (*a*) and a section (taken on the line *A B*) or interior elevation (*b*) of the elevator car, the design of which is simple and inexpensive, while the construction is substantial and serviceable.

The plan (*a*) shows two recesses *a*, *a*, in which are located the guides, thus permitting the car to extend the full width of the shaft. The frame of the car is composed mostly of wrought-iron pipe, as shown at *b* in the plan, between the vertical members of which small channels *c* are secured to receive the basketwork and grilles. On the inside of the car the guides are covered with sheet-iron dado panels, extending 2 feet 9 inches above the floor and with a beveled plate-glass mirror from here to the top of the car. The rest of the side walls of the car, with the exception of the door, is composed entirely of grille-work.

24. The dado consists of a simple basketwork of 1½-inch iron straps, spaced ¾ inch apart and secured by riveting the end of each strap to the leg of a 1-inch angle iron, as shown at *f*, Fig. 43 (*b*). The space between the dado and the grille-work consists of a sheet-iron panel secured in place by riveting it to the vertical legs of two 1-inch angle irons, which are framed in between the vertical supports.

The grilles forming the upper part of the elevator are composed of $\frac{1}{2}'' \times \frac{3}{16}''$ bars *d*, which are held vertically in place by means of $1'' \times \frac{1}{4}''$ horizontal rails *e*, through which the vertical members extend. By arranging the rails in pairs and keeping their distance apart equal to the spaces between the vertical members, a series of squares is formed, in which rings are inserted, as shown at *g*, thus bracing the joint and rendering the entire grille stiff and secure. Across the middle of the grille, a series of scroll ornaments *h* relieves the plainness of the panel, while at the same time it gives lateral stiffness to the vertical bars. At the top of the wall panels a scroll design *k* forms a frieze at the ceiling line, and it serves to combine the character of the side walls with that of the domed roof. The grilles of the roof are of simple twisted strap iron, such as described in Art. **5**, and scrollwork.



Folding Gate
(a)

Russia Iron Bottom.
(b)

(c)
Section of Guide Box.

Section of Folding Gate
(e)

(d)
Section through Side of Car.

Plan of Folding Gate.

FIG. 44

25. In Fig. 44 (*d*) is shown a section through the side of the car, illustrating on a larger scale the details of its construction. The rectangular floor frame is composed of 3-inch **Z** bars, as shown at *a*, and three thicknesses of wood flooring, lined with a Russia-iron shield *b*, resting on the lower flange of the **Z** bar, while the walls of the car are secured to its upper flange. The corner and intermediate supports *g*, composed of $1\frac{5}{16}$-inch wrought-iron pipe, are secured to the upper flange of the **Z** bar *a* at the floor level, and to a $\frac{1}{4}$-inch wrought-iron plate *l* at the top. This is accomplished by plugging the ends of the pipes with wrought-iron blocks and riveting the blocks in place through the pipe, as shown dotted at *c*. The ends of the plugging blocks are then cut with a screw thread and the nuts *h* turned up on them, after their insertion through the flange and plate. Two 1-inch angle irons *i* form the upper and lower members of the frame for the base and middle rail, as shown, and a 1-inch channel, extending full length of the sides and across the top of each panel, fastens the grilles and scrolls in their places. A smaller channel *k* rests on top of the plate *l* and receives the lower ends of the vertical members of the roof grille *o*. At *m*, another channel set vertically receives the upper ends of the vertical members of the roof grille, and also the ends of the straps forming the center ceiling panel shown at *l*, Fig. 43 (*a*). The straps of the dome and ceiling grilles are $\frac{1}{2}''$ × $\frac{3}{16}''$ iron twisted as shown, and are riveted where they cross at *j*, as described in Art. **5**.

26. In Fig. 44 (*c*) is shown a section through the panel and guide at the side of the car, the line *a b* being the center line through the guides. The angle irons *d* are fastened to the flange of the **Z** bar at the bottom and to the $\frac{1}{4}$-inch plate at the top by means of small angle-iron knees, and a plate of sheet iron *e* riveted to the short legs of the angles forms the back of the chase or guide recess. On the inside of the car a mirror is fastened to this plate by means of $\frac{5}{8}''$ × $\frac{1}{4}''$ angle irons screwed to the back of the chase with countersunk screw bolts.

27. An elevation of the sliding or folding gate, protecting the entrance to the car, is shown in Fig. 44 (*a*), while Fig. 44 (*e*) shows a large scale detail of the bottom of the sliding post of the gate *n* and the guide *o* in which it slides. The vertical members of the gate are each composed of a pair of $\frac{1}{2}$-inch channels, as shown at *a* in Fig. 44 (*f*), which is

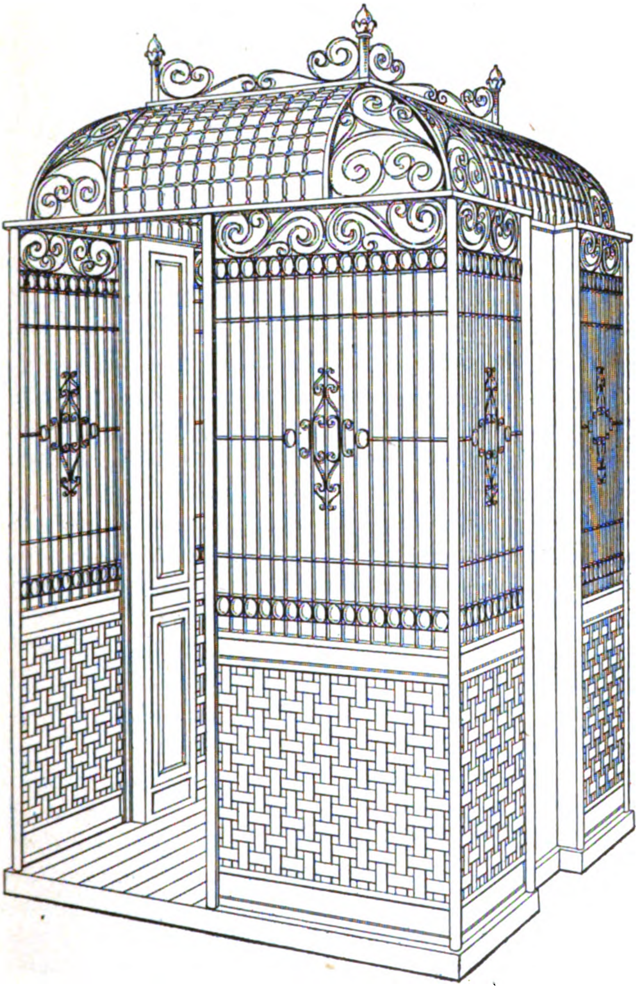


FIG. 45

an enlarged plan. Between these channels, the diagonal lattice bars *b* are secured as shown, with washers *c* between them to prevent their rubbing together as the gate is opened and shut. The rivets securing this latticework to the channels are not driven tight, but are left sufficiently free to play up and down in the slotted openings *a* shown in the elevation, Fig. 44 (*a*). Thus, the gate, which effectively bars the 2′ 7¾″ opening in the car, occupies only the width of the seven vertical channels, or 3½ inches when folded together so as to open the elevator. On the exterior channel, a ½″ × ¼″ guide is riveted, as shown at *n* in Fig. 44 (*e*), and on the under side of the **Z**-bar flange a track *o* is secured for the guide to travel in. At the top of the gate, the ½-inch channels are carried up each side of the frieze grille of the car, as shown at *b*, Fig. 44 (*a*), and also in Fig. 44 (*e*), where the lower bar of the frieze grille is shown at *g* and the side bars or channels at *p*. The general appearance of the completed car with all of its parts assembled, is illustrated in Fig. 45.

28. In Fig. 46 is shown a reproduction of a shop drawing of one of these cars, which was to be one of several all constructed alike, and accounts for the excess of material stated on the drawing for the different parts. This car is designed for a similar disposition of tracks and guides as the last example, but the design is more elaborate. The bottom of the car shown at *a* in the interior elevation (*a*) is of wood; the upright framing is of square tubes, as shown at *b* in the plan (*b*), inside of which an iron rod *c* passes through the floor and the cornice *d*, and secures these parts as shown in Fig. 46 (*a*). The framework is bound together horizontally by rods at the rail and base, as shown in the elevation (*d*) at *e*, and by the cornice at the top. Similar rods are placed in the corners behind the projecting panels on each side, thus binding the whole car together. The top of the car is of sheet iron, and, being dome-shaped, is self-supporting. The sides of the car are of cast iron below the rail, and cast and wrought iron above, with a mirror on each side. The small section of front adjoining the door shown in the plan (*b*) at *s*

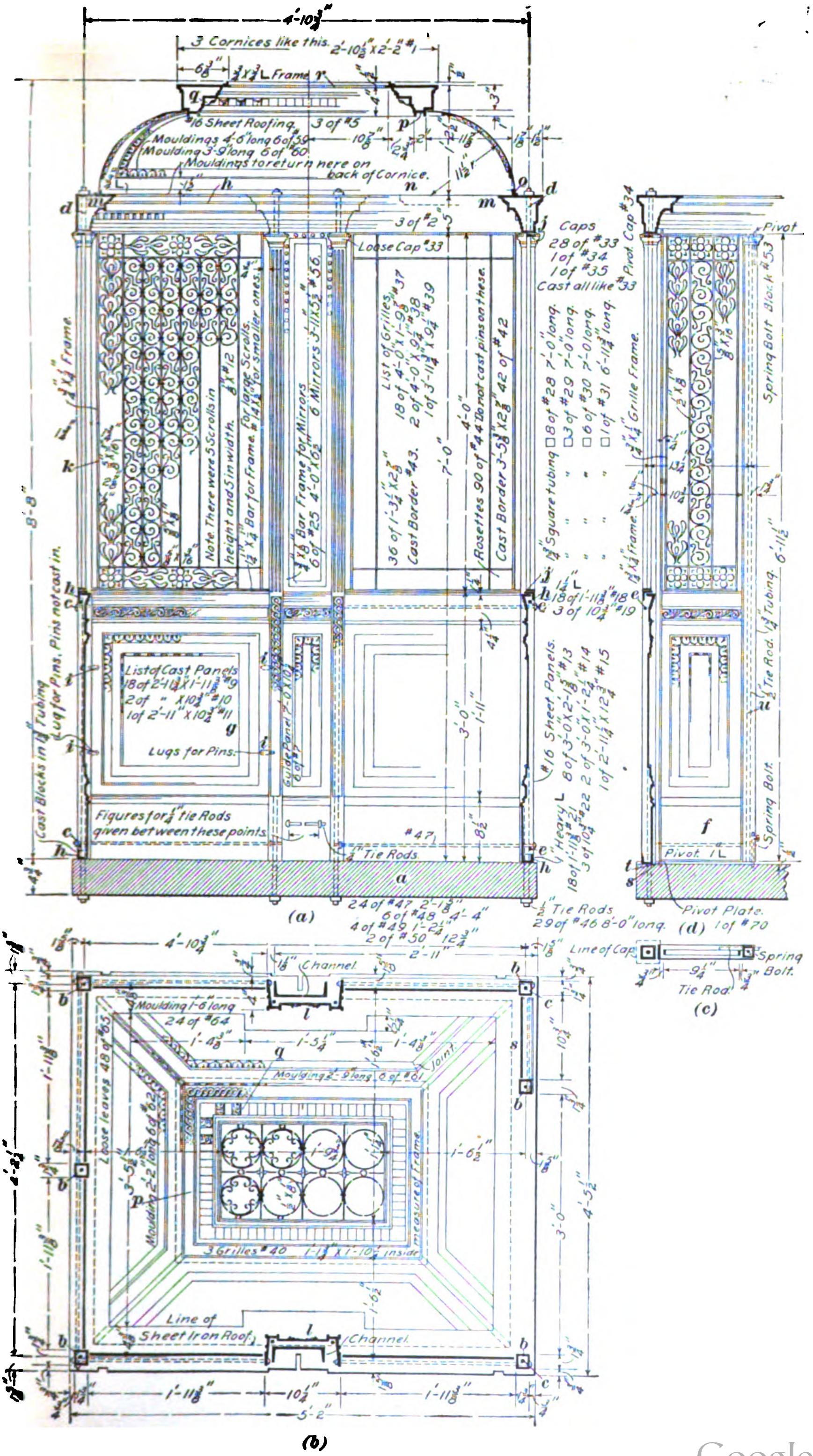
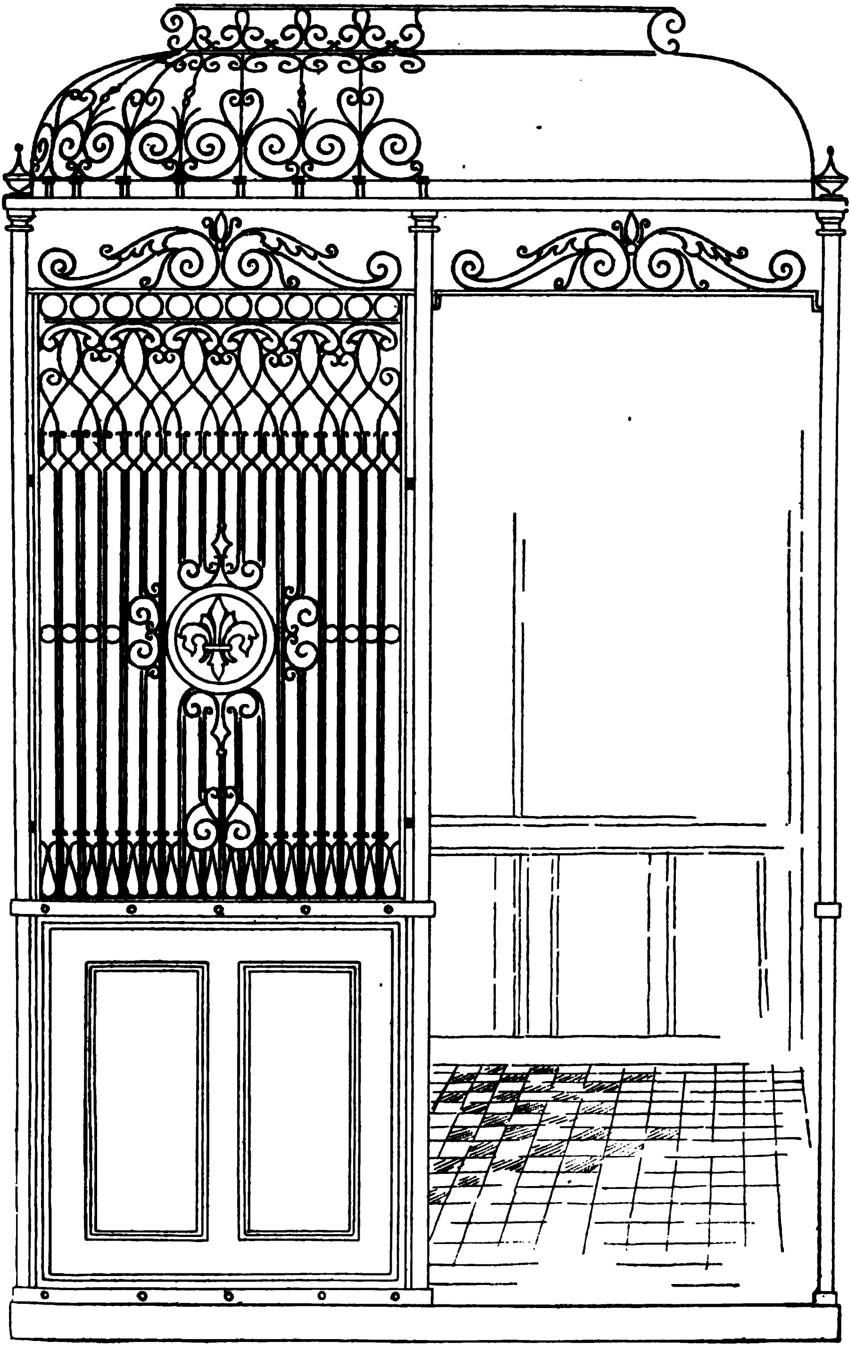

4'-10¾"
3 Cornices like this. 2'-10½" X 2'-2" #1
6⅞"
¾" X ¾" L Frame
r
q
p
#16 Sheet Roofing
3 of #5
10⅞"
Mouldings 4'-6" long 6 of #59
Moulding 3'-9" long 6 of #60
Mouldings to return here on back of Cornice.
h
n
o
d
m
11½"
3 of #2
Loose Cap #33
Caps
28 of #33
1 of #34
1 of #35
Cast all like #33
Pivot Cap #34
Pivot
Spring Bolt Block #53
¾" X ⅛" Frame.
k
8'-8"
Note. There were 5 Scrolls in height and 5 in width.
¾" X #12
1¾" X ¼" Bar for Frame. # 1¼" for large Scrolls, for smaller ones.
1" X ⅛" Bar Frame for Mirrors 6 of #25 4'-0" X 6½"
6 Mirrors 3'-11¾" X 5½" #56
List of Grilles
18 of 4'-0" X 1'-9⅞" #37
2 of 4'-0" X 9¾" #38
1 of 3'-11¾" X 9¾" #39
36 of 1'-3¼" X 2⅞"
Cast Border #43.
7'-0"
4'-0"
Rosettes 90 of #44 Do not cast pins on these.
Cast Border 3'-5⅞" X 2⅞" 42 of #42
1⅛" Square tubing □ 8 of #28 7'-0" long.
□ 3 of #29 7'-0" long.
□ 6 of #30 7'-0" long.
□ 1 of #31 6'-11¾" long.
1⅛" X ¼" Grille Frame.
1¾" X ¼" Frame.
6'-11½"
1½" Tubing.
½" Tie Rod.
u
Spring Bolt.
Pivot 1 L
f
1½" L
18 of 1'-11⅞" #18
3 of 10¾" #19
j
c
e
4¼"
3'-0"
1'-11"
8½"
#16 Sheet Panels.
8 of 3'-0" X 2'-1⅞" #13
2 of 3'-0" X 1'-2¼" #14
1 of 2'-11¾" X 12¾" #15
¼" Heavy L
18 of 1'-11⅞" #21
3 of 10¾" #22
Cast Blocks in 1½" Tubing
Lug for Pins, Pins not cast in.
List of Cast Panels
18 of 2'-11¾" X 1'-11⅞" #9
2 of " X 10¾" #10
1 of 2'-11" X 10¾" #11
g
i
Lugs for Pins.
Guide Panel 7" 0" X 10¾"
6 of #57
Figures for ¼" tie Rods given between these points
#47
Tie Rods.
a
h
4⅜"
(a)
24 of #47 2'-1⅞"
6 of #48 4'-4"
4 of #49 1'-2¼"
2 of #50 12¾"
½" Tie Rods
29 of #46 8'-0" long.
Pivot Plate.
1 of #70
(d)
t
s
Line of Cap
9¼"
Tie Rod.
Spring Bolt.
(c)
1⅝"
4'-10¾"
1⅝" Channel.
2'-11"
b
Moulding 1'-6" long 24 of #64
1'-4⅞"
1'-5¼"
1'-4⅞"
Joint.
Moulding 2'-9" long 6 of #61
Loose leaves 48 of #65
Moulding 2'-2" long 6 of #62
1'-11⅞"
6'-2¼"
3'-5½"
1'-9¾"
1'-6½"
½" X ⅛"
3 Grilles #40 1'-1¾" X 1'-10" inside measure of Frame.
10¾"
3'-0"
4'-5½"
1'-6½"
Line of Sheet Iron Roof.
Channel.
l
1'-11⅞"
10¾"
1'-11⅞"
5'-2"
(b)

FIG. 46

is made to swing inwards, to allow the use of the full width of the car in handling merchandise. The outside of the car below the rail is covered with sheet iron. The dado of the side shown at *g* in the elevation (*a*) is cast in one piece, including the base, panel, frieze, and cap. The base and cap are plain molded; the outside molding of the panel is decorated with a link leaf and the inner with a spool-and-reed ornament. The casting is fastened at the top and bottom by bolts through the angle irons *h*, which are framed in between, and bolted to, each pair of corner posts. At the sides, the panels are held by small lugs cast on them to receive dowel-pins, as shown at *i*, elevation (*a*). The top and bottom of the outside frames for the grilles shown at *j*, elevation (*a*), are made of $1\frac{1}{4}'' \times \frac{1}{4}''$ bar iron, and the sides *k* of $\frac{3}{4}'' \times \frac{1}{4}''$ iron. The inside frame dividing the cast-iron border and the grille is of $\frac{5}{8}'' \times \frac{3}{16}''$ iron, as shown; the bars of the grille are $\frac{5}{8}$ in. × $\frac{1}{8}$ in., and the scrolls are all $\frac{1}{8}$ inch thick. The cast-iron border of the grille is a laurel-leaf design with a rosette in each corner and in the center of the top and bottom sections. The scrolls are fastened to the frame by rivets; but to the bars, they are held by straps. The cast-iron guide box, shown at *l* in the plan (*b*), is strengthened at the corners and finished on the inside with a pilaster, the upper part or shaft of which is fluted and finished with a cap, while the pedestal is paneled and filled with a guilloche ornament. The cornice is of cast iron, molded and ornamented with a dentil course, as shown on the interior elevation, while on the back it is finished with small moldings top and bottom, which return as indicated by the dotted lines *n*. The dome plates are mitered at the angles and paneled on the inside face. The miters are covered with bronze spool-and-reed moldings, and the panel molding is decorated with a leaf link. The dome plates are secured to the vertical leg of an angle *o*, which is riveted to the top of the cornice of the car; and the cast-iron cornice of the dome is supported by these dome plates. The soffit of this dome cornice is decorated with a guilloche, as shown at *p* in the plan, while its fascia and corona are supported on modillion brackets, as



47

FIG. 47

shown at *q*. The dome grille *r*, elevation (*a*), is designed suggestive of the usual treatment of a ceiling, being first divided into panels, which are afterwards filled with a circle, and the circle with a quarterfoil of scrolls. This grille is set in an angle-iron frame, which is bolted to the cornice. The swinging door shown in the plan at *s* is seen in elevation at (*d*). The pivots *s* are riveted to the frame of the grille, the top one being inserted in the cornice and the bottom one in the pivot plate *t*. The top and bottom of the post *u* are fitted with spring bolts, which are withdrawn when the section is to be opened.

By a careful inspection of the details of the preceding examples, the construction of elevator cars should now be fully comprehended; and, as such work does not differ materially, there should be no difficulty in designing the construction details of any car required.

29. In Fig. 47 is shown a design for an elevator car entirely of wrought iron. The grille differs from the previous examples, as it has no border, but is divided into a dado, field, and frieze. The dado is composed of a series of oval scrolls, the field has a cartouch with a fleur-de-lis in the center, and the frieze is an interwoven pattern, surmounted by a series of rings. The panels that take the place of the cornice are filled with scrolls and decorated with leaves having a flower or bud at the center. The grille of the dome is in motive similar to the honeysuckle decoration used in classic architecture.

The car illustrated in Fig. 48 is of wrought iron, and the dado is a diaper of basketwork. The grille, by the arrangement of the scrolls, does away with a border top and bottom, but, as it is divided into three panels having the bars gathered reed fashion, it is necessary that a border be provided to close the space at the sides. The rods forming the reeds are separated by button washers and are riveted together. The dome of this car is circular in plan, and is divided into a series of radiating panels that finish at the bottom with a link-scroll design and at the top with rings. The crown of the dome has the scrolls so arranged that they form a natural continuation of the panels.

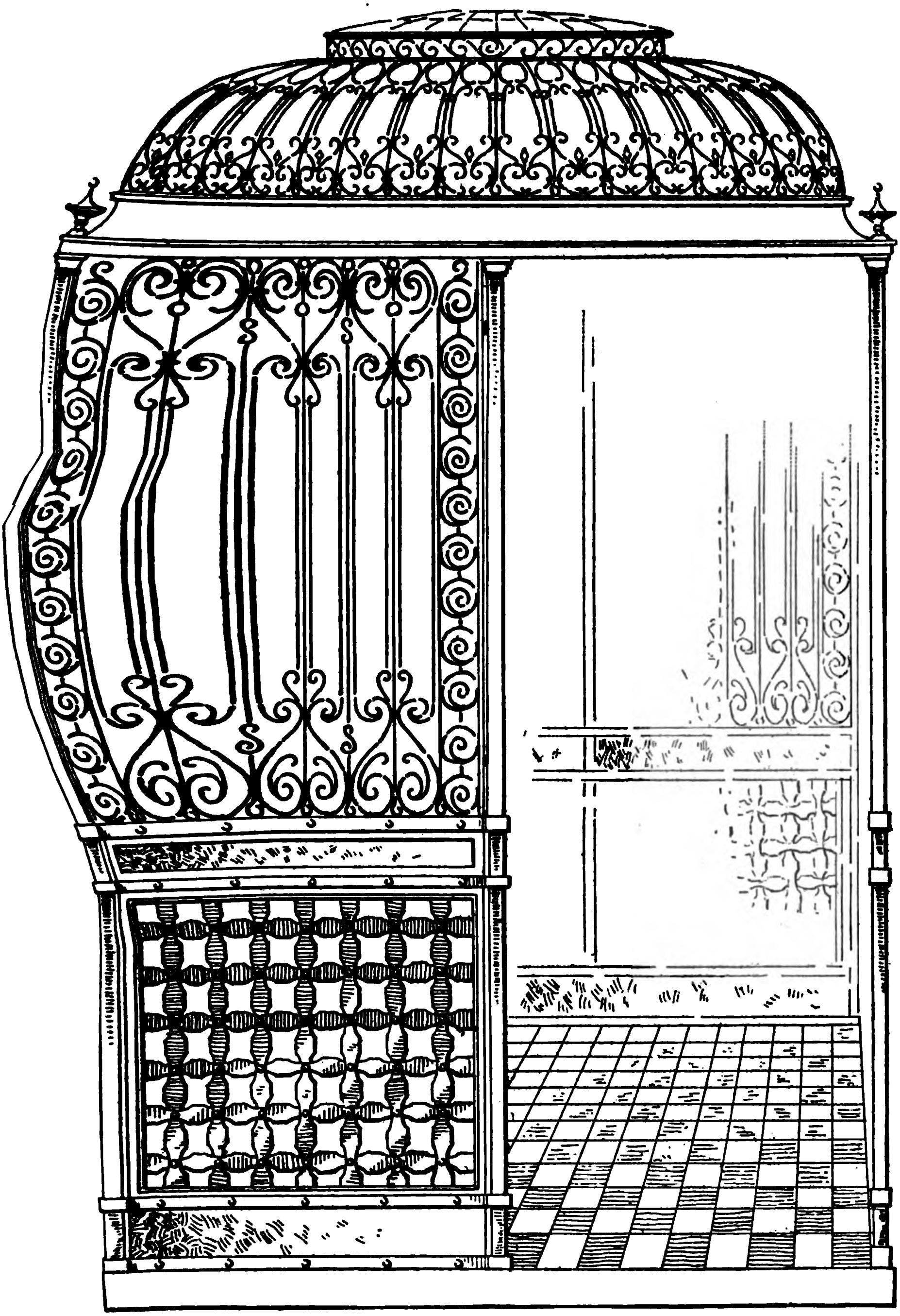


FIG. 48

LEAVES AND FOLIATED WORK

30. All the work considered up to the present time has been purely structural. Such ornament as has been necessary in elevator fronts or office partitions has been of a conventional character, and is confined to strap-iron grilles. Now, however, another kind of ornamental ironwork will be considered, namely, the execution of leaves and flowers in sheet and bar iron, by means of forging and working the metal. No machinery is required for this work, and to produce satisfactory results, a knowledge of designs, methods, and tools in use are indispensable.

In this branch of wrought-iron work, the designer should be intimately acquainted with his material; he should know how much working his metal will stand under certain conditions, and how much working his design will require to bring it into shape. He should know at what point and under what conditions forging will be necessary, how much of the work can be formed cold, and what details will have to be executed with the metal at a red or a white heat. Wrought-iron leaves are usually executed in sheet metal and hammered into shape; flowers sometimes require both sheet and bar metal; while designs of foliated grille-work require sheet, bar, and strap iron in varying quantities, according to the character of the work.

31. In Fig. 49 is shown a finished leaf as it would appear when permanently placed in position. To reproduce this leaf in iron, it will first be necessary to make a developed drawing of it—that is, a drawing of the leaf as it would appear if flattened out to the original shape of the metal when first cut out, before working in any manner. It is hardly possible to lay it out exactly—and in fact, such accuracy is not required, for, if the general dimensions are correct, the other parts may be worked into shape in subsequent

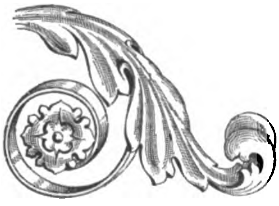


FIG. 49

operations. In Fig. 50 is shown the general appearance of the developed drawing. This drawing should now be carefully traced on the sheet metal and cut out. The crude iron leaf is then placed on a block of soft metal, such as lead, and cold-hammered into the general shape required. As constant hammering is likely to make the metal brittle and hard, it is sometimes necessary to anneal the iron in the forge several times before the leaf is finished. Special forms of hammers are used to shape the work. Two of these hammers are shown in Fig. 51. The one at (*a*) is flat on both faces, and is used in the general shaping of the leaf; while the one at (*b*), which has a spherical head, is used to produce the curves of the lobes and indentations, and to bring the leaf to its finished form. The flared face opposite the spherical head is brought into service when sharp indentations or veins are to be formed, though for this purpose other tools and punches are also used in connection with the work.

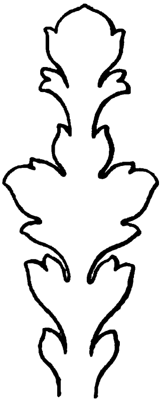


FIG. 50

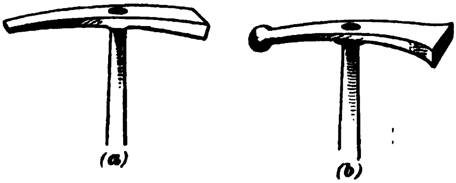


FIG. 51

32. In designing leafwork for a grille, a gate, or a railing, consideration should always be given to the appropriateness of its position in accordance with the utility of the device and the architectural style of the building. For instance, in the elevator cars and enclosures heretofore discussed, little or no consideration has been given to wrought-iron leafwork, because an elevator is essentially a utilitarian device, and such ornamental features as are expressed in its design should be a part and detail of the necessities of its construction. The grilled sides of the elevator are rendered ornamental by simply twisting the iron straps and bars of the frame filling into geometrical forms; but where a grille is inserted in a transom light, or over a gateway, merely as a finish and ornament to the opening, the design may be elaborated with leafwork, as the purpose of the grille is not utilitarian but ornamental. Again, the heavy gates of a carriage entranceway require some leaf decoration to harmonize with the design of their surroundings, but they should at the same time preserve their identity as a purely utilitarian detail. The leaves and tendrils should not be delicately modeled in thin metal, but should be boldly hammered from sheet iron of from $\frac{3}{32}$ to $\frac{5}{32}$ inch in thickness. There should be no feeling of frailty in such a detail, and the ornament should be as strong and serviceable as the main structural details of the gate.

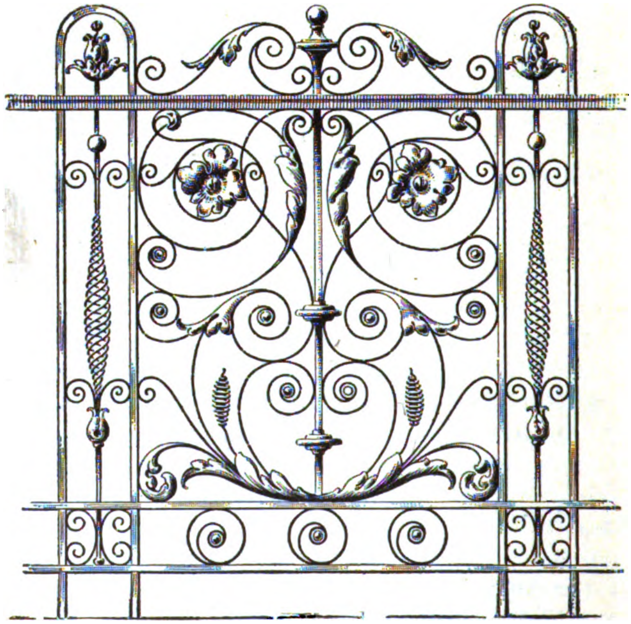


FIG. 52

33. In Fig. 52 is shown the design of a panel suitable for a light railing, or a protecting grille in front of a glass screen.

The lines of the design are too delicate to permit of its use in a position where it would receive hard usage, and its details may therefore be of very light materials. The main framework, it will be observed, is composed of substantial bar iron, while the filling and leafwork is of very light gauge. The treatment of the panel shown in Fig. 53 is the reverse of this. Heavy framework filled in with substantially proportioned scrolls and bars forms the general scheme of the design, while the leafwork is applied to the parts where the scrolls unite, and thereby renders the points of forging more pleasing to the eye. The leafwork in this design plays no part in the structural strength, but renders

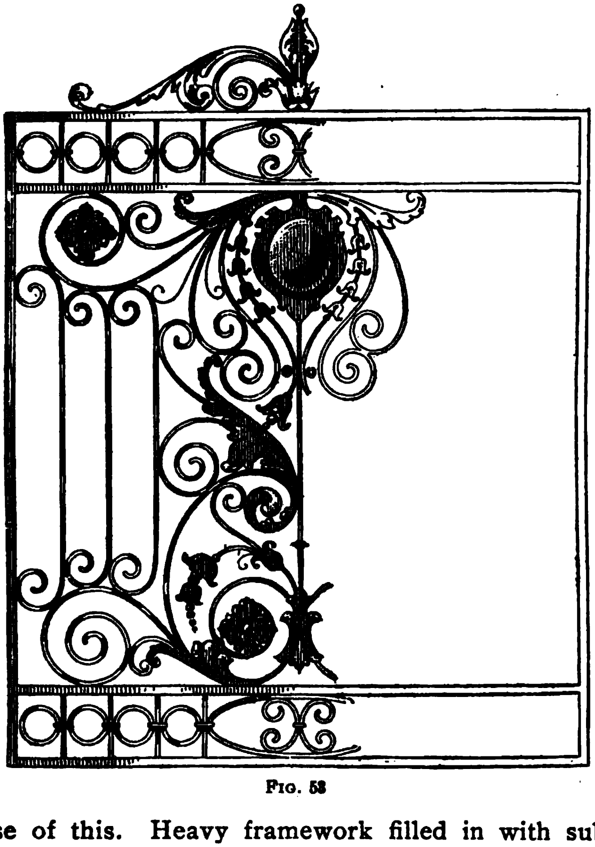


FIG. 53

the structural necessities artistic, by combining and uniting them under an artistic form.

These two examples, Figs. 52 and 53, are intended to show the two principal conditions to be met with in leafwork design. Fig. 52 shows a framework full of ornament, possessing little strength and mainly serving an ornamental purpose, while Fig. 53 shows a strong frame and rigid grille-work, certain details of which are emphasized with leaf design. In Fig. 53, strength is the main consideration, and the ornament clothes the utilitarian details in artistic forms.

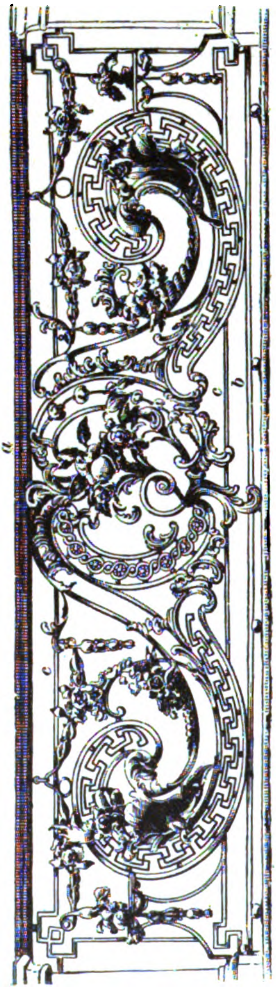


FIG. 54

34. In Fig. 54 is shown a piece of wrought-iron work that exceeds, in elaboration of design, anything heretofore considered. It is a design for one panel of a railing, placed in front of a window in a modern flat building, and is intended to be supported at each end by a heavy stone pier or pilaster. The top rail *a* and the bottom rail *b* extend from one of these posts to the other in an unbroken line, while the inner rail *c* is broken by the lines of the main scrolls, and is worked into a fret design in the corners. As the filling of this panel is nearly all leafwork, it follows that the leaves should be wrought in a heavy gauge of iron. The delicacy of the design will in no way be impaired by such treatment, as the parts should possess an appearance of strength sufficient to fulfil their several functions.

The main lines of the ornament in this design are composed of heavy iron bars, to which the leafwork is secured by forging. The double lines of the large scrolls forming the scheme of design at each end are filled in with a fret ornament of light iron. The iron of the main scroll being wider than that of the fret, the latter is protected from injury, but is raised from its support on button washers, in order that it may be more readily seen. The same may be said of the guilloche ornament on the left side of the center scroll, but the stem-and-bud ornament on the right side of the centerpiece is bent in place independent of the surrounding bars.

The leafwork is forged to the structural details as shown, and therefore seems to form a natural part of them, though the style of leaf is of a debased system of design. The example, however, serves to illustrate the extremes to which wrought-iron-work designs may be carried, and the tasks that a skilful workman may be called on to carry out.

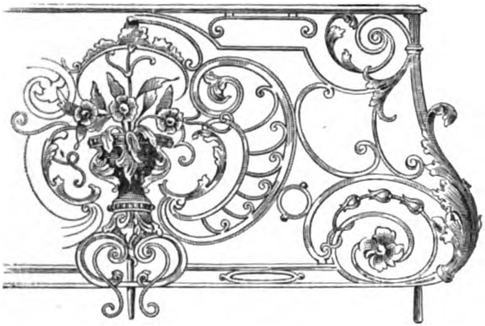


FIG. 55

Fig. 55 shows another design that, though less ornate in its leafwork, is equally complex in the arrangement and management of its scrolls. The main scroll lines break and change their direction suddenly, thereby leaving some points improperly secured, and necessitating other scrolls to hold them in place. The centerpiece is executed entirely in sheet metal, the drooping leaves being fastened to the surface of the vase with rivets. The main leaf of the scroll on the right-hand end of the rail is somewhat similar to the one shown in

Fig. 49, though larger. In this position, it forms an ornate finish to the panel, and at the same time serves as a floral calyx out of which the lower lines of the scroll appear to naturally grow.

FORGED WORK

35. In the succeeding pages, descriptions of the illustrations given cannot be more than general, as the principal object is to give examples that are standards of artistic and ornamental design. Instruction in smithwork has not been attempted, nor has it been deemed advisable to try to cover the complete field of useful and ornamental objects made in wrought iron, but to discuss only a small number of the ones more commonly seen and used in house building.

That a knowledge of the tools and the methods employed in working iron may be made known, and that the designs shown may thereby be better understood, the following short description is given: The few primary tools consist of a forge, an anvil, a pair of tongs, an ordinary blacksmith's hammer, a fuller, a set of punches (say three sizes each of square and round), three swage hammers, a set hammer, a flatter, and a riveting hammer. The fuller and the swage hammers are usually called *top swages*, as a duplicate of the hammer face, which fits in a hole in the top of the anvil, is called a *bottom fuller*, or *swage*.

The making of grilles and scrolls by bending and riveting is described under another head. Any two or more parts joined while hot are called *welded*, and all objects worked from a single piece are called *forged*. Whether welded or forged, the iron should first be brought to a white heat, and work commenced with the metal at this color, and continued until the iron assumes a deep cherry red, although, of course, this will depend somewhat on the grade of iron used. When the object to be welded or wrought is placed on the anvil, the blows at first should be light, and gradually increased in force as the metal cools, the forging would only be needlessly changed in shape by hammering not graduated in this way. This point may be appreciated by watching a good blacksmith at work.

To convert a section of a flat bar into a round one, the bar is brought to the proper heat in the forge fire and then laid across a bottom fuller set in the anvil, where, with a pair of tongs, it is held edge up, with the fuller hammer on the upper side. In this position it is indented until the approximate size of the round is made. The bar will now look as though it had a nick cut out of it on each side, the space between being the guide for the round part. The bar is again heated, and a bottom swage put in the hole in the top of the anvil, and the bar is placed on the anvil and worked to a rough round. It is then once more heated, and this time placed in the bottom swage, the smith holding the top swage in place while the helper strikes the top of it repeatedly as the bar is drawn between the swages, producing an even, smooth finish.

In the case of a fence railing or window guard, where the bars or pickets are to pass through the horizontal rails, and it is desired that the rails shall be of a uniform section where bars pass through, it is necessary that the rail shall be what is termed *upset*, that is, heated and driven together endwise to produce a bulge at the desired portion; or a small piece may be welded on at the point where each bar is to pass through to compensate for the metal punched out; the rail is then heated, and the required hole is made with a square or a round punch. After reheating, the rail is passed over the anvil and finished with the flatter to remove all the marks of the other tools.

If two bars are to be joined at right angles, they are placed one over the other at a white heat and welded together with a common smith's hammer, after which the slight bulging at the juncture is worked out. In especially fine work, a small piece is cut from each bar at the point of welding, though this is seldom necessary in ordinary practice.

Surface cuts, indentations, etc., for the production of diaper designs or patterns on plain surfaces, should be made at a low heat with fullers set in the bench, or anvil, as the case may require, a guide or spacer being so placed as to keep the work uniform and true. The finials of posts and knobs on fence bars are first roughly forged out by hand, and then placed in a die under a trip hammer; or, where this is not at hand, the die is struck with sledges. When small work is welded, the tool marks are removed by the set hammer, which is simply a small flatter.

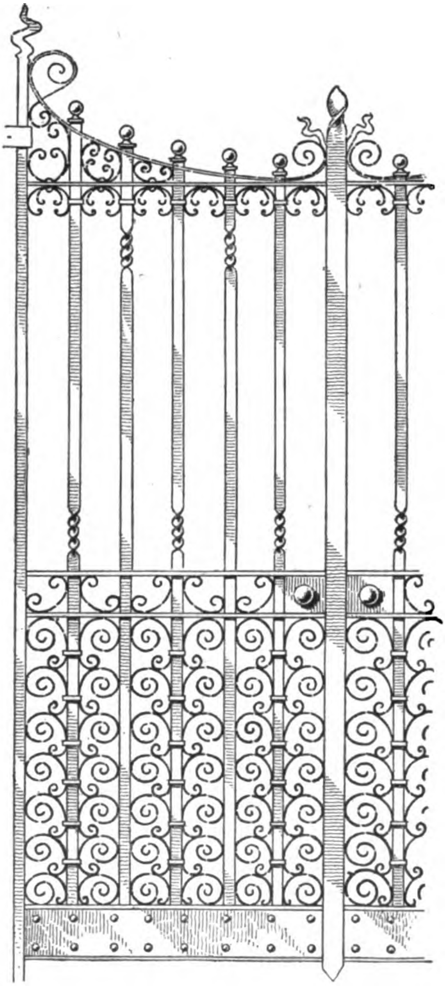


Fig. 56

36. In making festoons of leaves or flowers, or of both, a stem should first be made of the required length, and the pieces for the leaves cut from thin bar or strap iron, on which the individual stems of the flowers are welded. The shape of the leaf or flower is then worked out on a soft-metal block, as described for leafwork. When all the leaves and flowers are made, the main stem and a single leaf or flower are heated in the forge and welded together, this process being repeated with each leaf and flower until all are in place; they are then finished up and put in exact position or alinement after the metal is cold. When an object is to be forged out of a single piece of material, it is heated in the forge and worked under the hammer to the required shape or form; this is the most expensive part of wrought-iron work.

GATES AND FENCES

37. Most of the examples heretofore given have been of light work that could be made without heating the iron, but in Fig. 56 is shown ironwork of a more substantial character. The main bars are 1½ inches square; the cross-bars are 3 in. × 1½ in., wide enough for the uprights to pass through; and the scrollwork is of material ¼ in. × 1 in. When a bar is to be punched out, as in the horizontal members in this case, there should be ample metal left on each side of the hole punched to prevent the sides from spreading under the pressure of the punch and leaving the bar somewhat protruded at these points. The scrolls are alike in the lower part of the gate, and are fastened to the upright bars by a narrow strap on one side and a countersunk screw on the other. The hinge or hanger should be arranged at the top and made as shown in Fig. 57. The frame of the gate, which is a square bar, is rounded where the hinge clasps it, as shown at (*a*). The jagged part of the hinge is embedded in the stone piers or wall to which the gate is to be hung, and fixed in place with molten lead; or, where circumstances will permit, the bar is passed entirely through the wall and fastened on the other side with a large washer and nut. The gate is held by the clasp, which is secured with two bolts passing through the hinge bar, as shown at (*b*).

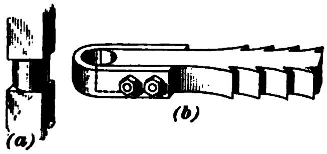


FIG. 57

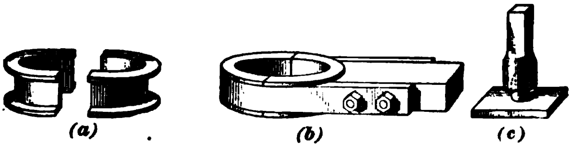


FIG. 58

In exceptionally high-grade work, the inside of the hinge is lined with a brass collar, as shown in Fig. 58 (*a*) and (*b*), which prevents the two surfaces from rusting when they are in contact. Nearly all gates, and especially heavy gates, are pivoted at the bottom; and the pivot is usually formed at the lower part, or *heel*, of the gate itself, and fits in a socket under the gate. The objection to this method is that the socket is likely to fill with dirt and make it difficult to move the gate. A better way is to make the socket a part of the gate, and have the pivot separate, as shown in Fig. 58 (*c*). An oil hole may then be bored through the socket in an oblique direction to the pivot, which may then be oiled; and, as the socket is in the gate, the dust and dirt cannot get in and clog it up.

38. The railing shown in Fig. 59 is a good example of forged work, and illustrates the application of leafwork without detracting from the lines of the fence. The main uprights and the horizontal rails are clearly defined, and, as they should be, are much heavier than the bars and scrolls filling the panels formed by them. The fence is divided into large panels or sections, one of them being a double gateway. The first two upright bars at the end of the panels are carried up, forming posts. An increase in the size of these bars would be an improvement and further emphasize the post effect. The top of the post is finished with a finial ornament, and the gate as well as the side panels are finished with a cresting. The cresting of the gates is arranged to group them as one panel, and the main scrolls are decorated with leafwork. The top and bottom of both the gates and panels are well braced with an open rail having a scroll let in between. The scrolls filling the top and bottom of the panels are finished with a leaf-and-bud ornament, and the bars are braced by three rows of rings secured with straps and screws. The posts from which the gates are hung are braced with triangular foot-braces, and these as well as the posts themselves are leaded into the stonework.

The gate shown in Fig. 60 is a vigorous, well-balanced design, decidedly German in character, and including in the design of its transom the German national emblem. The side panels of the screen, as well as the outside of the transom, are open and less elaborate than the central panels, the contrast between them heightening the effect by separating the rich carving that existed on the stone architrave from the elaborate iron grille of the center. The transom bar is in four panels, each of which is filled between the border frame and lower rail with grille-work composed of crossed scrolls and decorated with leaves and rosettes. The continuation of the principal vertical lines from the screen to the transom bar is accomplished by a console bracket, the top of which clasps the transom-bar rail. A point in this design that might be improved is the manner in which the inner frame of the semicircular transom border is carried down past the

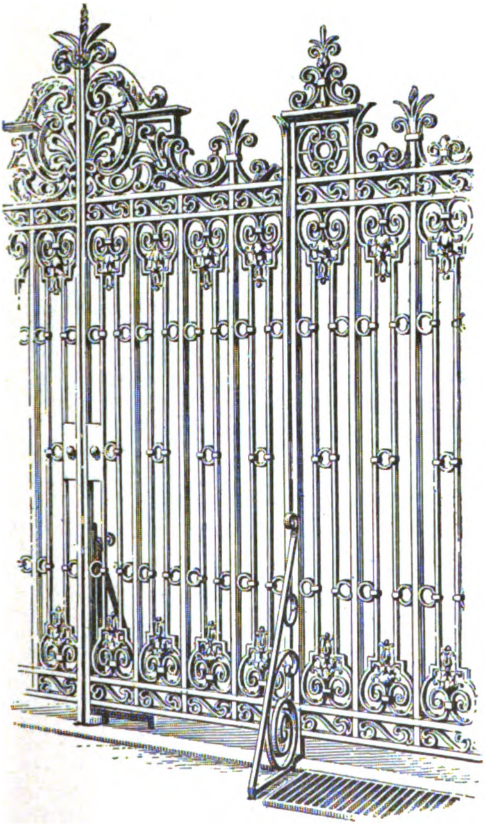


FIG. 59

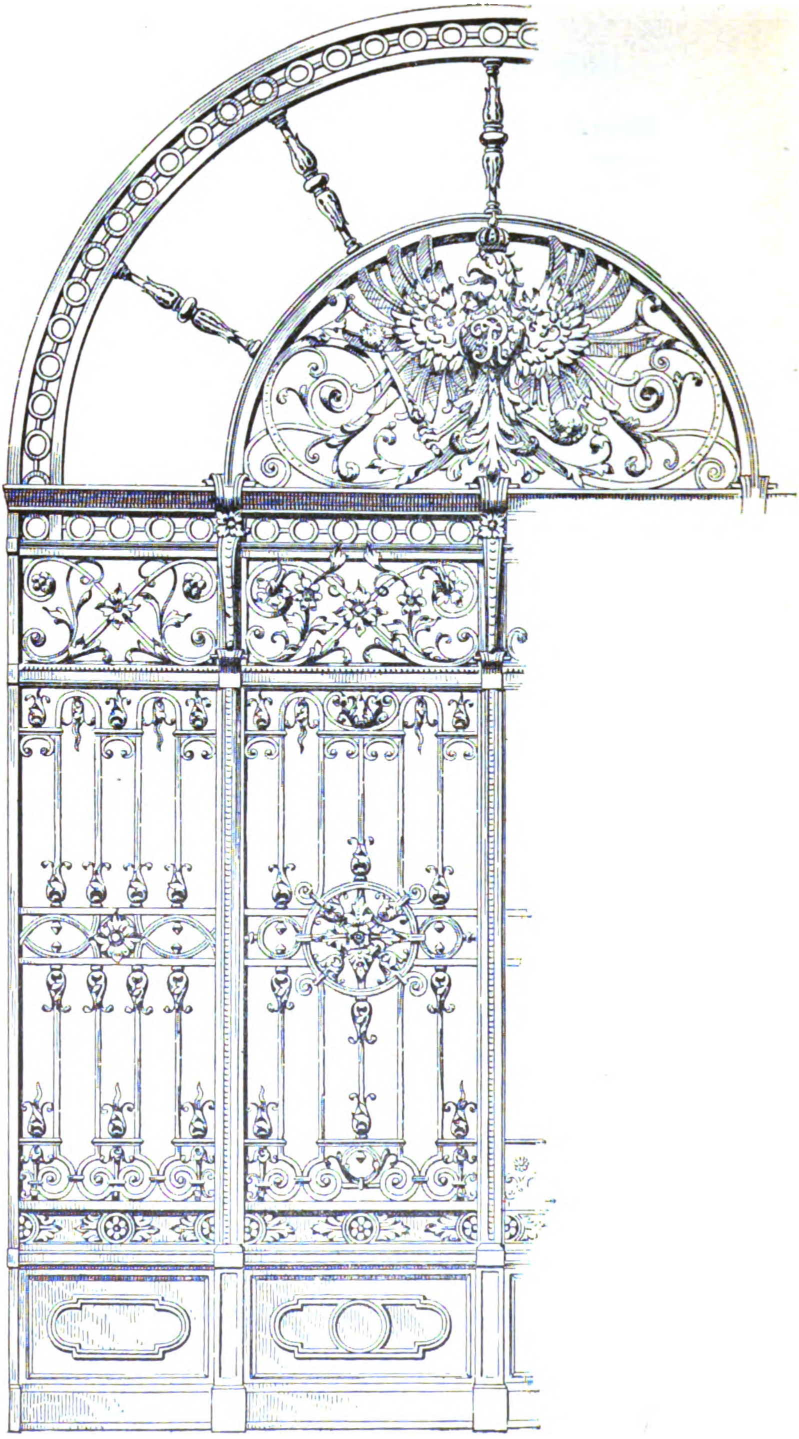


Fig. 60

top of the transom bar to the border frame, thus giving the idea that the transom frame is supported there; the omission of this piece of frame would considerably heighten the border effect and remove this weak appearance.

39. In Fig. 61 is an example of a small garden gate in cast iron, and, with the exception of the central shield and the ornament at the top, all the members are kept approximately the same general thickness, to avoid any danger of cracking during the cooling stage. The parts that appear heavier on the face are thinned out to preserve the balance of metal. Cast iron for small work of this kind is inferior to wrought iron, as the effect of contrasting heavy and delicate

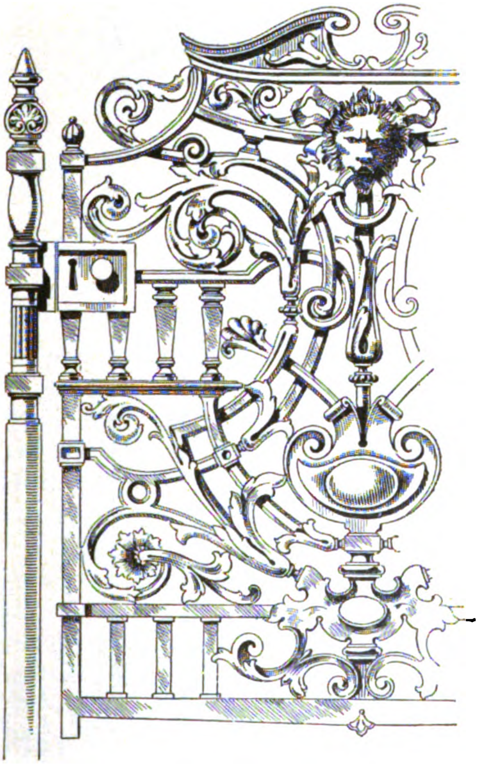


Fig. 61

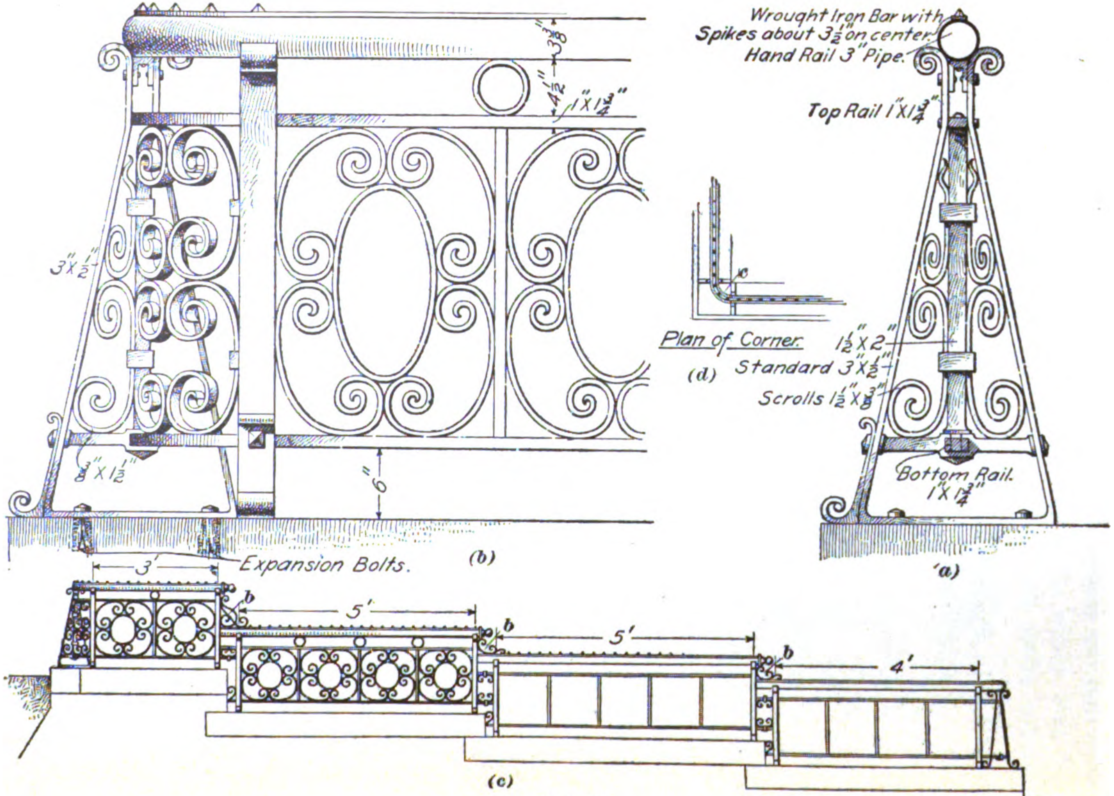

Wrought Iron Bar with Spikes about 3½" on center.
Hand Rail 3" Pipe.
Top Rail 1"×1¾"
1½"×2"
Standard 3"×½"
Scrolls 1½"×⅜"
Bottom Rail. 1"×1¾"
(a)
Plan of Corner.
(d)
c
3⅜"
4½"
1"×1¾"
3"×½"
⅜"×1½"
6"
Expansion Bolts.
(b)
3'
5'
5'
4'
b
b
b
(c)

FIG. 62

features is necessarily somewhat wanting, owing to the limitations of the material.

The railing shown in Fig. 62 is a very massive and well proportioned one. The posts, or supports, are made triangular in shape, as shown at (*a*), and would almost retain their position without the aid of the expansion bolts by which they are secured to the coping, as shown at (*b*). This railing tops a stepped coping, as shown at (*c*), and is joined by easy and graceful scrolls at the point of the step *b*. The corners are arranged as at *c* in the plan (*d*), and the grille is bent to the radius formed by the intersection of the supports at their bases. The hand rail is a wrought-iron pipe finished at the ends with a knob ornament, and the top has a bar studded with spikes to prevent lounging.

WINDOW GUARDS

40. A **window guard** should be primarily a protective device, and secondarily an ornament or decoration. As a rule, especially in private-residence work, the design of these very necessary features is not given a proper amount of attention, but they are certainly as deserving of careful consideration as any other ironwork of the structure. They may be made to form the divisions of the window opening in place of the bars of the sash, and to produce the desired effect of window subdivision, at the same time leaving the glass in any required size. It is not necessary that a window guard shall be flat, nor set between the jambs of the window opening; it may be a roomy addition to the window sill, fastened to the walls on either side of the jambs, wherein summer flowers may be placed to blossom in the sun and receive protection from high winds or careless hands. Small openings for ventilation or light may be rendered pleasing by simple and effective guards, such as those shown in Fig. 63 (*a*), (*b*), and (*c*), cut out of single pieces of iron.

The guard shown in Fig. 63 (*d*) is a clever piece of forging, and illustrates what simple and yet refined design may be executed in this class of work. The upper and lower

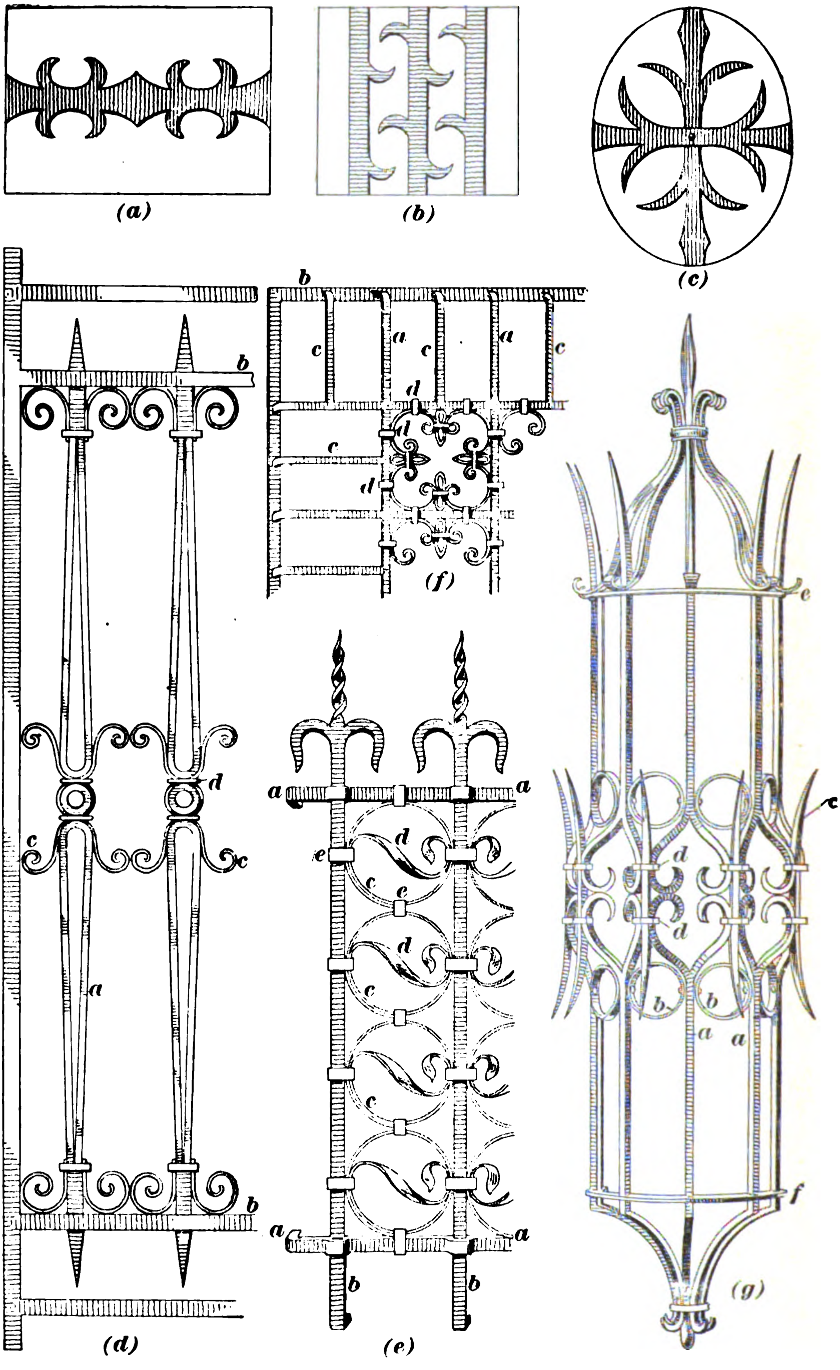


FIG. 63.

parts of the bars *a* are made by bending the iron into long open loops as shown, the ends being carried through the rails *b*, a ring forged between the two interior ends, and the scrolls *c* forged to the bars and ring; the clip, or clasp, *d* encircles both ring and scroll, and binds them together.

The design shown in Fig. 63 (*e*) is very old in style, and is made to fasten to the face of the walls surrounding the window opening, the rails *a* and bars *b* being provided with return ends, which are let into the stonework about 6 inches from the edge of the window opening. The rings *c* forming the grille in this design are carried about a quarter-turn past the full circle, and the iron is twisted and flattened out in the center to form a leaf scroll *d*, which, with the rings and bars, is held in place by the flat clips *e*. The bars are drawn out and cut into three prongs at the top to form a cresting, the center one being twisted and the other two bent down to give ample protection to the top of the opening.

The design shown in Fig. 63 (*f*) is constructed for use either on the wooden window frame or on the face of the wall surrounding the window. The bars *a* forming the large square mesh are welded together, and extend beyond the mesh a distance equal to its width, and are then bent back 4 inches and welded to the frame *b*; intermediate pieces *c* are set between them, and a border is thus formed. The angles of the mesh are filled with scrolls as shown, which are held in place with flat clips *d*.

41. The guard shown in Fig. 63 (*g*) is an example of how effectively iron may be employed in decorating an otherwise plain opening, and transforming it into one of the attractive features of a house front. This guard is intended to cover a small window opening, which would almost escape observation without it, and certainly add nothing to the design of the building, though necessary for lighting the interior. This guard is made up entirely of different sizes of bar iron. The principal feature is the manner in which the bars *a* are divided just above the circles *b*, which are riveted to them, the divided portions being wrought into scrolls,

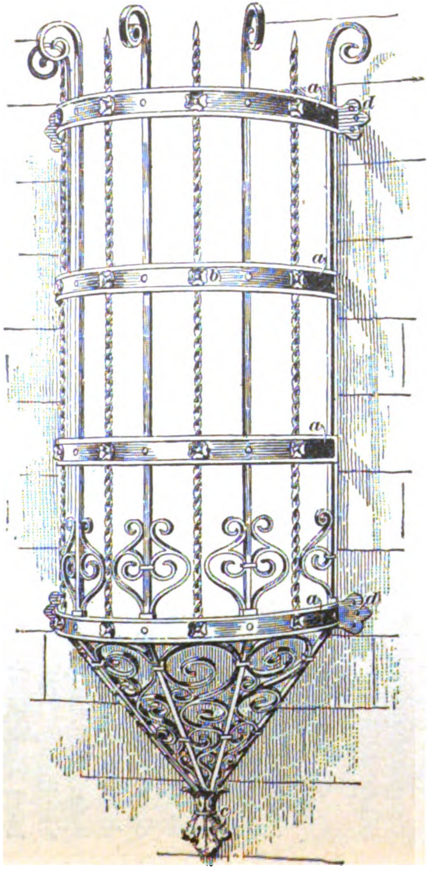


FIG. 64

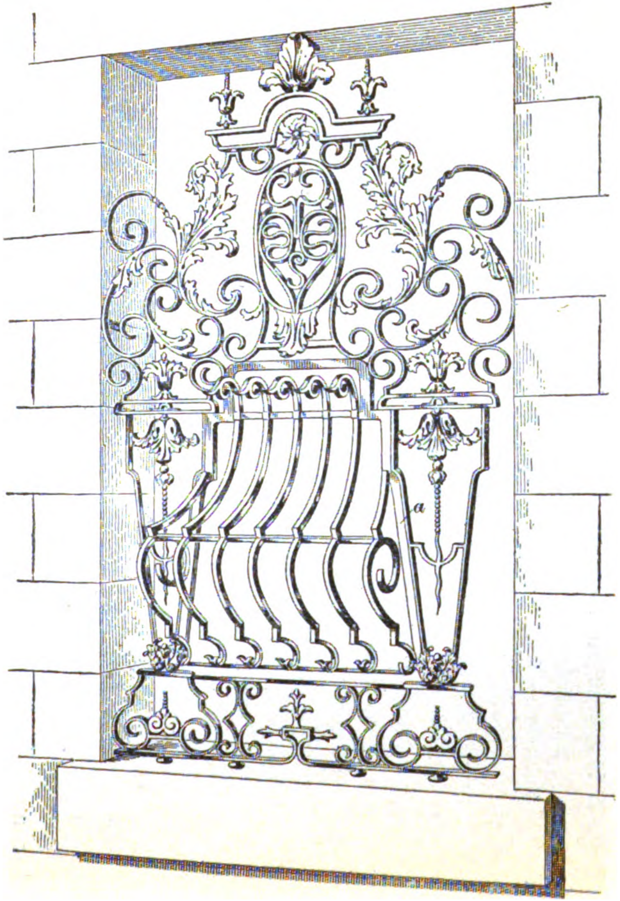


FIG. 65

which are welded to the spikes *c*, and are further bound by the strap clips *d*. The tops of the bars are finished with spike points, passing through a band *e* and through the bars forming the top, and are welded together. The guard is attached to the opening by the ends of the bands *e* and *f* bent to form lugs, which are calked with lead into holes cut for them in the stone jambs.

In the guard shown in Fig. 64, the horizontal bands *a* not only greatly increase the protection, but, with the ornamental studs or rosettes on their faces, add much to the decorative effect. These studs *b* are riveted on over each twisted bar. The edges of the bands are turned over, forming a border or flange, strengthening and giving them a finish. The twisted bars terminate at the lower band, and the plain bars are carried down, all meeting in a point, where they are welded together and covered at the junction with a leaf ornament *c*. The twisted bars are pointed at the top, and the plain ones are finished with a scroll. The entire lower portion of the guard is filled with a scroll grille, and a dado of scrolls is filled in between the bars above the lower band. The guard is fastened to the stone with expansion bolts let into the stonework through the ornamental bolt plates *d*.

42. The design shown in Fig. 65 has many points in its favor from both a structural and an ornamental standpoint. It is constructed almost entirely of forged bar iron, with just sufficient leafwork to relieve the monotony of single lines. The design is so open that the interference with light, ventilation, or outlook is inconsiderable; but at the same time it is strong, secure, and well adapted to its prime purpose as a guard. The presence of the leafwork in the upper part gives this device an appearance of lightness and delicacy, but observation will reveal that behind these leaves heavy wrought bars give the strength that the purpose of the device requires.

43. The preceding window guards are all designed for the purpose of preventing access to the building, where the windows can be easily reached from the outside; but guards are also placed across window openings at the higher stories where the sills are very low, to insure safety against the possibility of any one falling therefrom. They are used also merely as part of the ornamentation of the façades of buildings, although this practice is hardly defensible. Figs. 66 and 67 belong to this class, the former being entirely of wrought iron. Fig. 67 is mostly of cast iron with wrought-iron framing bars. The two main posts are doweled into the stone sill, and the top bars are screwed to the iron window jambs at each side. It is made thoroughly rigid by being braced back to the two mullions.

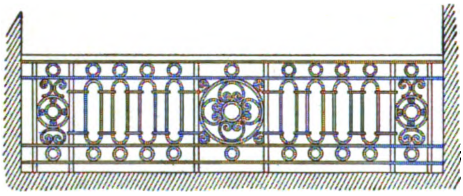


FIG. 66

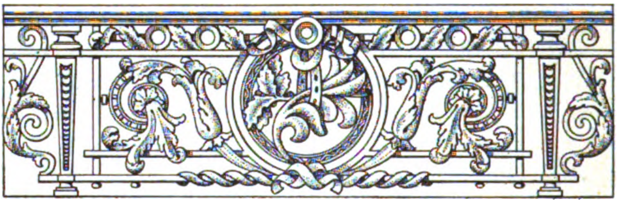


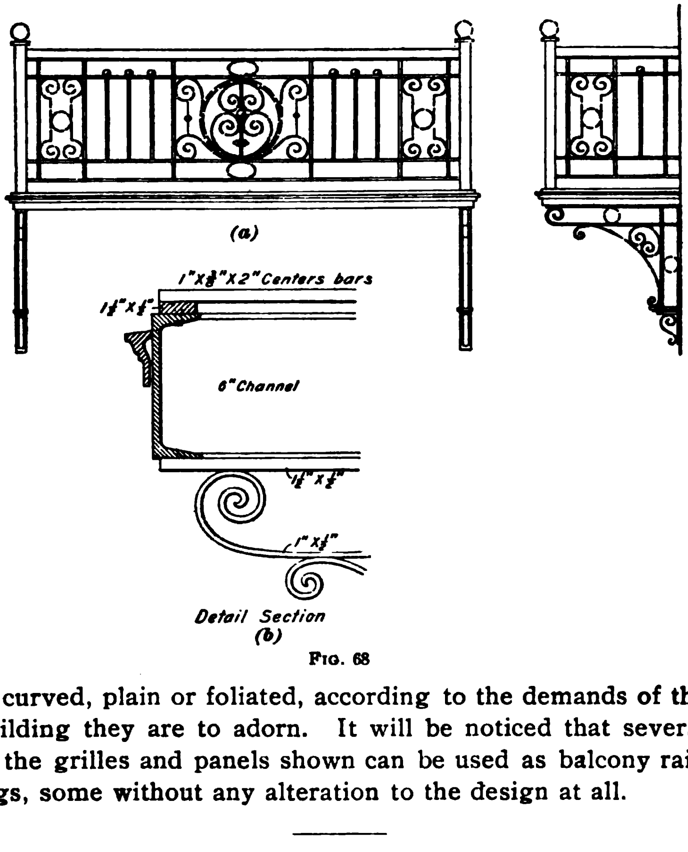
FIG. 67

BALCONIES

44. Balconies of stone or of wood often add to the appearance of a building, but they lack the light and graceful effect of those made of iron.

In Fig. 68 (*a*) is shown a light balcony very simple in design, that is made entirely of wrought iron. The floor is composed of flat bars spaced 1 inch apart. Along the face of the wall is a light angle iron, which is bolted to the stonework. The front and ends are formed of 6-inch channels supported on brackets, as shown in Fig. 68 (*b*), the face of the channels being relieved by a small molding. The railing is composed of 2″ × ½″ horizontal bars, ¾-inch square vertical bars, and ¾″ × ¼″ scrolls; it is capped with a 2½-inch brass-pipe rail resting on a 2-inch channel. The corner posts are 2½ inches square, surmounted with a brass ball.

Balcony work, like all other ornamental ironwork, has a wide range, and embraces every design from the simple one just described to the massive continuous example shown in *Ornamental Metal Work*, Part 1. The railings may be straight or curved, plain or foliated, according to the demands of the building they are to adorn. It will be noticed that several of the grilles and panels shown can be used as balcony railings, some without any alteration to the design at all.



Detail Section
(b)

FIG. 68

LAMPS AND BRACKETS

45. For exterior and interior lamp posts and brackets, wrought scroll-and-leaf work lends itself most readily. There is no detail of house furnishings wherein wrought iron can be put to such effective use in decoration as in electric and gas fixtures. The necessary presence of the wire conduit or gas pipe forms the purely utilitarian element of the design, and is so easily disposed of that the designer may devote nearly all his energies to the perfection of the ornamental details and the grouping in the composition. It may be well also to state that in addition to the ironwork itself another consideration materially affects this style of design, and that is the forms of electric lamps and globes with which the fixtures are to be furnished. Electric lamps may be obtained in all sizes and styles, from the large 300-candlepower, strictly for commercial use, to the small single- and half-candlepower globes used for decorative purposes. The latter are frequently mounted on the end of white-glass tubes blown in representation of wax candles, a number of which are grouped in one candelabrum or bracket, diffusing the soft unobtrusive glow of old-fashioned candle light, without the offensive grease, smoke, or smell. Again, these same diminutive lamps are enclosed in china globes representative of various flowers, such as the rose, lily, morning glory, etc., and the bracket that supports them is correspondingly designed to suggest the details of the foliated bush or vine.

46. The lamp in most common use is the 16-candlepower size, and Fig. 69 shows the neat arrangement of one of these globes at the end of a wrought-iron wall bracket. The design is extremely simple; the tube containing the wires extends in a curve from the wall to the lamp. Iron scrolls appear to emerge from the small foliated wall plate with the tube, and help support it on the outside, while the

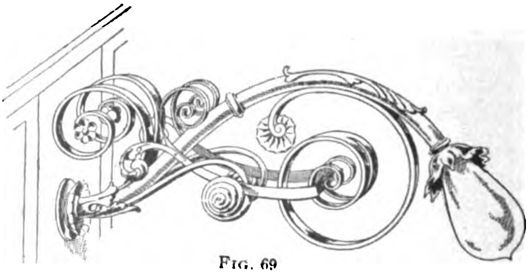


FIG. 69

lamp is so set that its light will not cast the shadow of any part of the fixture.

Fig. 70 shows a similar design, somewhat more ornate, though precisely the same in principle. The tube, or conduit, forms, as it protrudes from the leafwork, the main stem of a floral device, from which scrolls branch out at each side, and at the termination of which is the blossom consisting of a 16-candlepower lamp, surrounded by a calyx of wrought-iron leaves. The essential points of difference between Figs. 69 and 70 lie in the fact that the former consists almost entirely of strap-iron scrolls, while the latter is primarily a foliated design the scrolls of which exist as a part of the floral composition, and do not, as in Fig. 69, form the structural scheme of the design. The long wall plate in Fig. 70 renders this bracket much stiffer than the former one, particularly as the scroll on the curve of the conduit tends to tie the wall plate and bracket in two places. The scrolls in Fig. 69 might serve a similar purpose, but not without impairing the desired effect of a single tube springing abruptly from the wall surface.

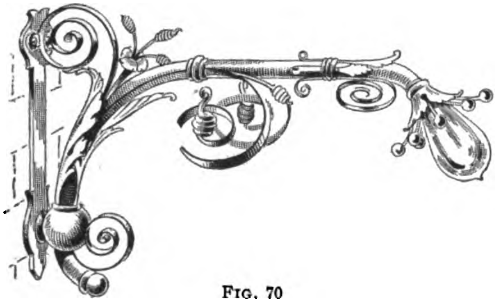


FIG. 70

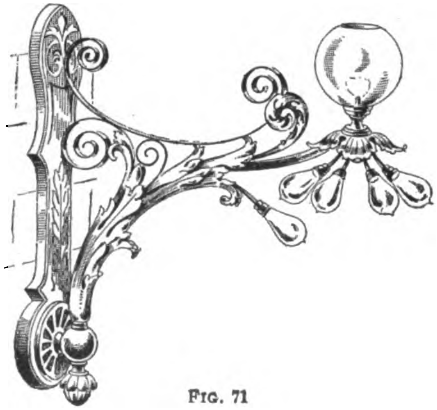


FIG. 71

47. In Fig. 71 is illustrated a combination bracket designed for both gas and electric light. Here the wall plate is much heavier, and though the general scheme of design is similar to the example shown in Fig. 70, the leaf and ornamental work is heavier, as is required by the presence of more electric lamps and a gas globe. The main tube, or conduit, contains both the electric wires and the gas pipe, and as it terminates in a spray of four lamps and one gas jet, it must appear sufficiently strong and well proportioned to carry these details successfully; hence, the extra leafwork to give its body bulk and weight, together with the scrolls that appear to support it from above. Behind these is the wall plate that apparently carries the weight of all, and is therefore made bold and substantial in proportion to the work it has to do.

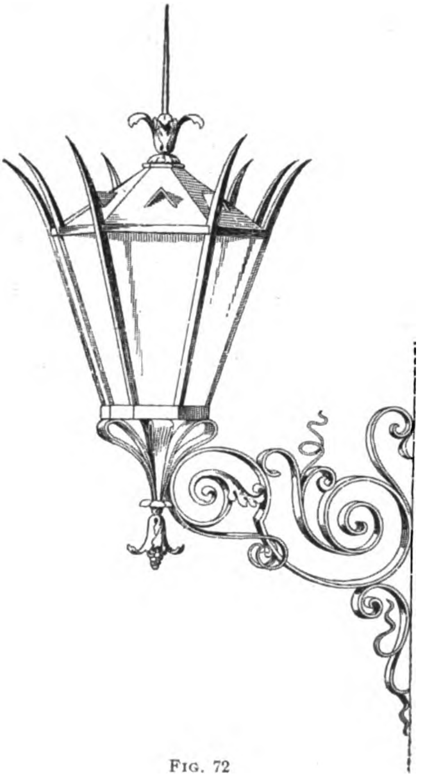


FIG. 72

48. Bracket and gate lanterns of various forms are used on the entrance posts flanking a gate, or are suspended over the gate by means of a scrollwork arch. Fig. 72 shows a bracket lamp, the body of which is made of sheet iron and glass. The pyramidal sheet-iron roof—or *canopy*, as it is sometimes called—is pierced by eight small ventilators and is finished on top with a foliated finial. The scrollwork connecting the lantern to the wall is composed entirely of strapwork, and is secured to

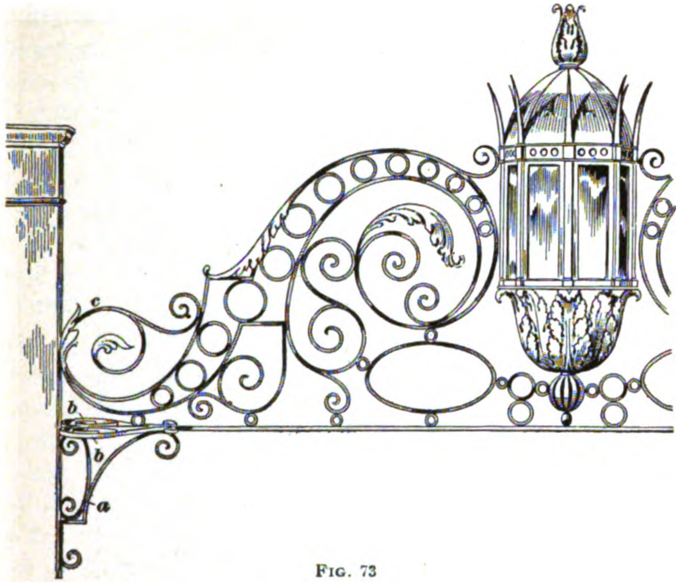


FIG. 73

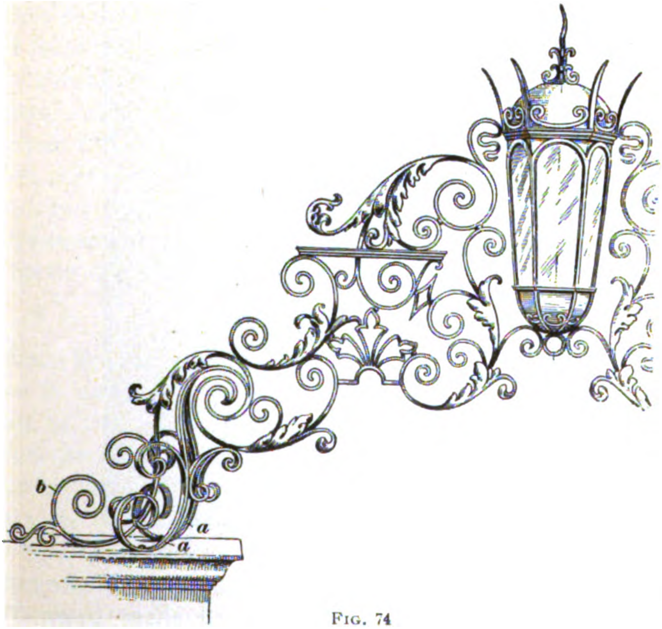


FIG. 74

the masonry by means of expansion bolts. Strength and simplicity are the fundamental principles to be looked out for in this class of work.

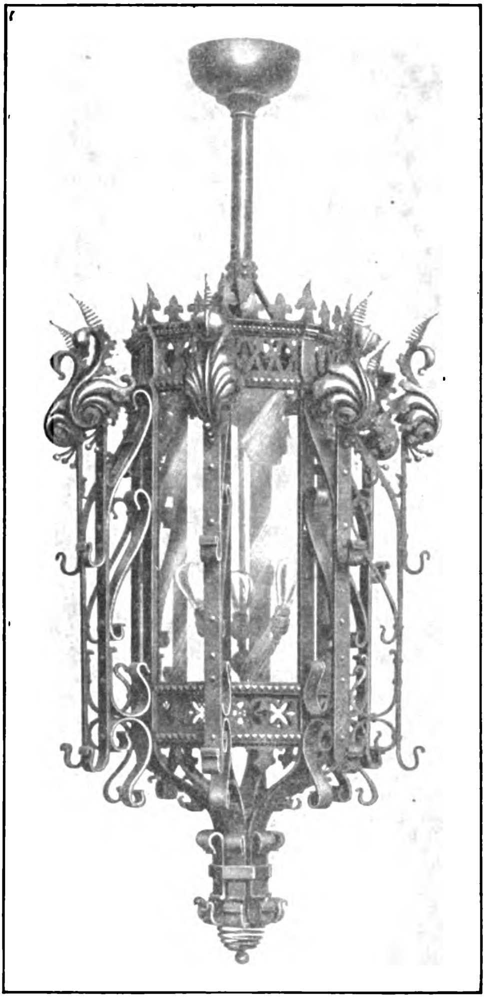


FIG. 75

The gateway lanterns shown in Figs. 73 and 74 are made of a combination of cast, wrought, and sheet iron. The design shown in Fig. 73 is intended to be placed between gate posts, and is provided with the bracket scrolls *a* to distribute and support the weight with the scrolls *b* to brace the grille laterally, and with the scroll *c* to prevent any tendency toward a rotary movement. The iron arch in Fig. 74 is designed to rest on the top of gate posts, and the scrolls *a* are so arranged at the foot of the arch that they prevent any lateral movement or tendency to revolve, the weight being well distributed and also a firmer hold being obtained by extending the large scroll *b*.

49. A very beautiful design of a wrought-iron pendant lantern is shown in Fig. 75. It is intended to hang under an archway or any similar position. It will be agreed that the primary use of a lantern is to shed light; and if this were all, then such a design as here shown would not fulfil the condition to the best advantage. But this is not all. Lights may be very properly used decoratively as well as for purposes of illumination, and this is a case in point. The light serves the purpose of marking the middle of the archway, and since that is all that is desired, the designer has felt able to elaborate and beautify the inner case by the addition of sprays and bands with graceful, hammered leaves. This is another illustration of what has already been stated, to the effect that the successful designer should constantly bear in mind, not only the individual article he may be engaged on at the moment, but its real object, whether entirely utilitarian or partly decorative, and its relation to its environment.

LAMP POSTS

50. Brackets and hanging lanterns, however, cannot be used in every case, and naturally the next form to suggest itself is that of a post, or column, which may be either a single shaft or a central shaft with clusters of brackets surrounding it. These posts may be short or long, slender or massive, sometimes forming the termination of the stone posts of a gateway or may be in the shape of a candelabra set on the stonework of an entrance. Fig. 76 illustrates an example of the former while Fig. 77 shows the candelabra type.

51. Fig. 78 shows a form of lamp post, the design of which is suggestive of a giant candelabrum. The base and shaft of cast iron are octagonal in plan, and support the three spherical globes containing the electric lamps. The arms supporting the globes are simply designed with just a suggestion of foliated work in the details. The globe may be of opalescent or ground glass, in order to diffuse the light from the electric lamps within, of which there may be three or more to each globe, according to the illuminating requirements. This style of lamp post is frequently used as a luminant for the porch of a private residence, hotel, or club, but for street lighting where the arc light is used, a different form of post is required, owing both to the difference in the form of the lamp and to the care attendant on its maintenance. Fig. 79 shows the style of support suitable for the latter case. It is executed in cast iron, as was the design shown in the previous example, but owing to the difference of its purpose the entire character of the design is changed.

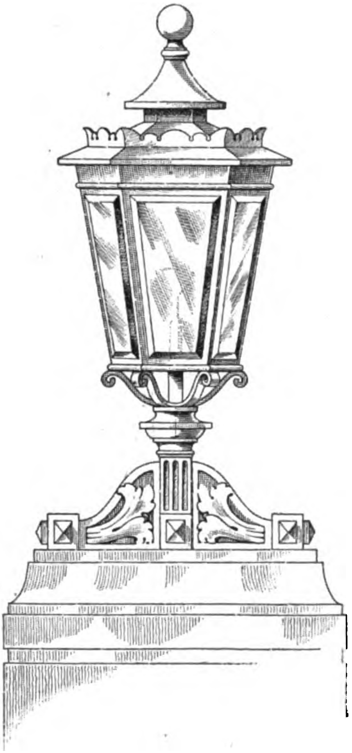


Fig. 76

In the first place, the post shown in Fig. 79 is much heavier and bulkier than the one in Fig. 78 for the reason that it is likely to receive somewhat rough usage from passing vehicles or careless draymen. Posts for street use should never be made so slender as to be easily broken. The upper portion of the post shown in Fig. 79 is designed as a loop or wicket, in which the arc light hangs under a protective roof, or hood.

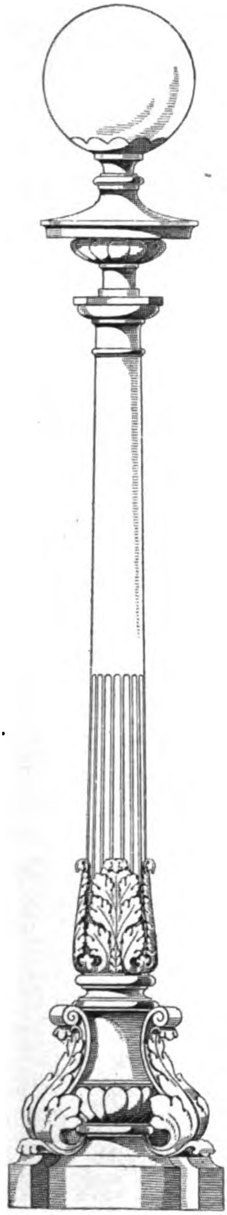


FIG. 77

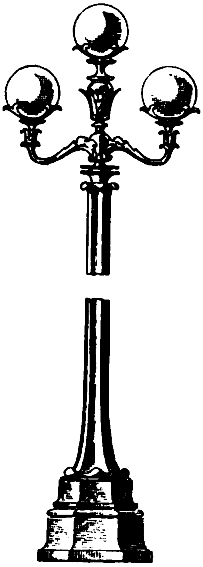


FIG. 78

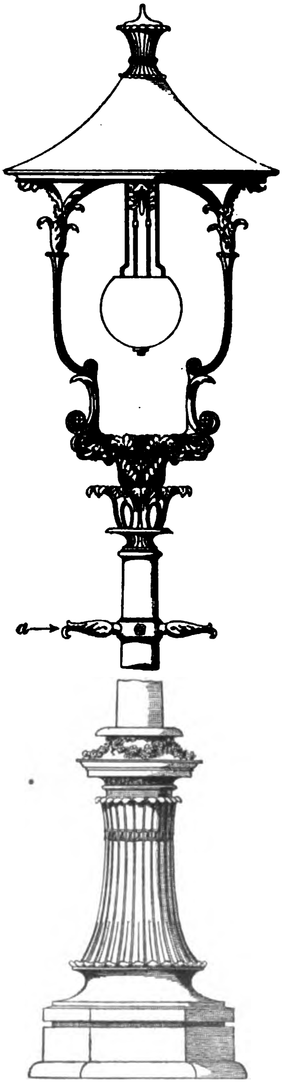


FIG. 79

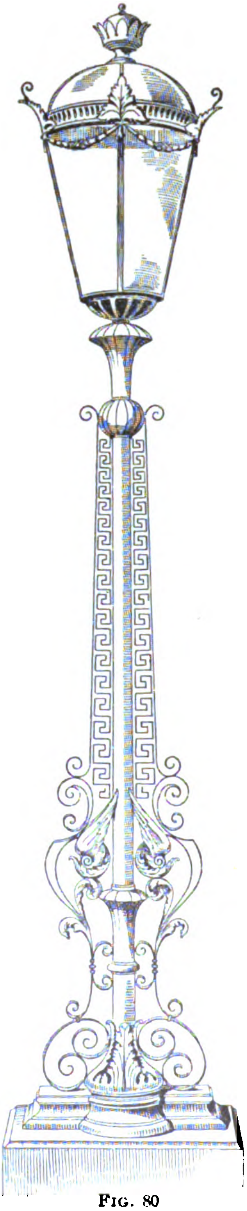


FIG. 80

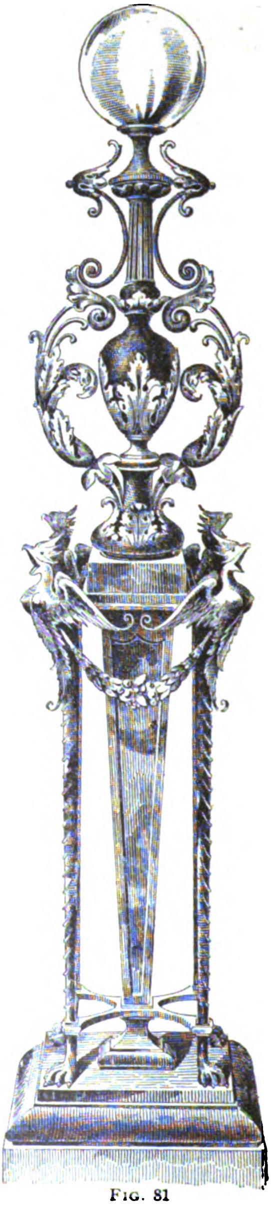
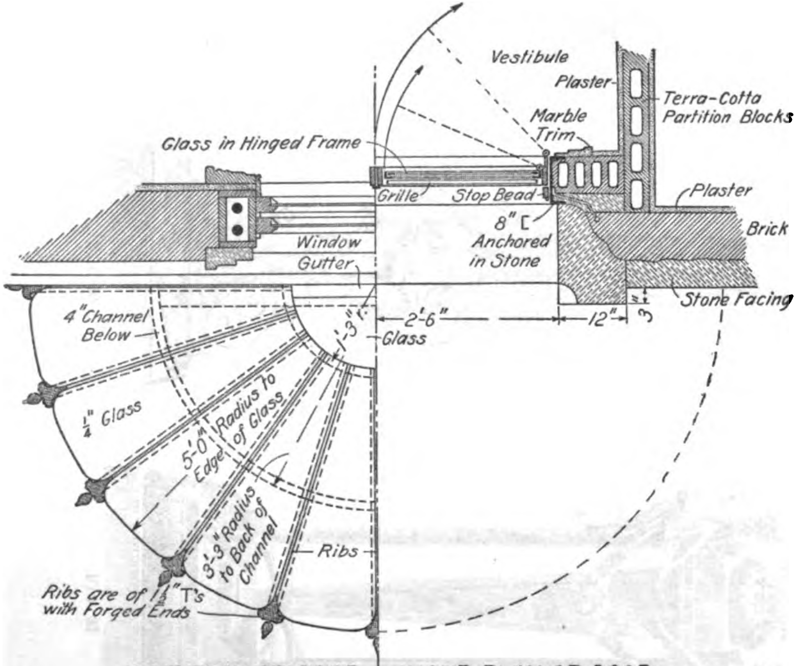
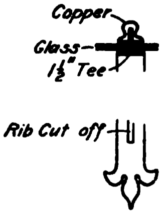


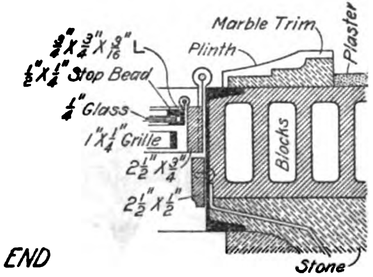
FIG. 81



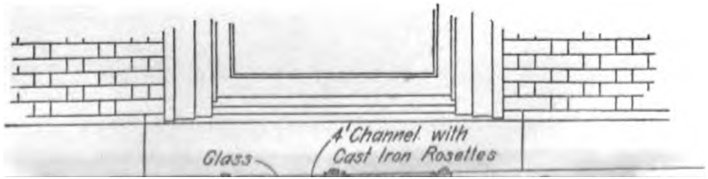
HALF PLAN OF ROOF | HALF PLAN OF DOOR

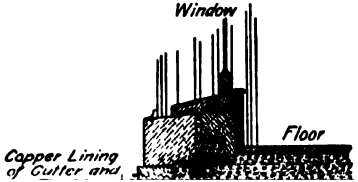


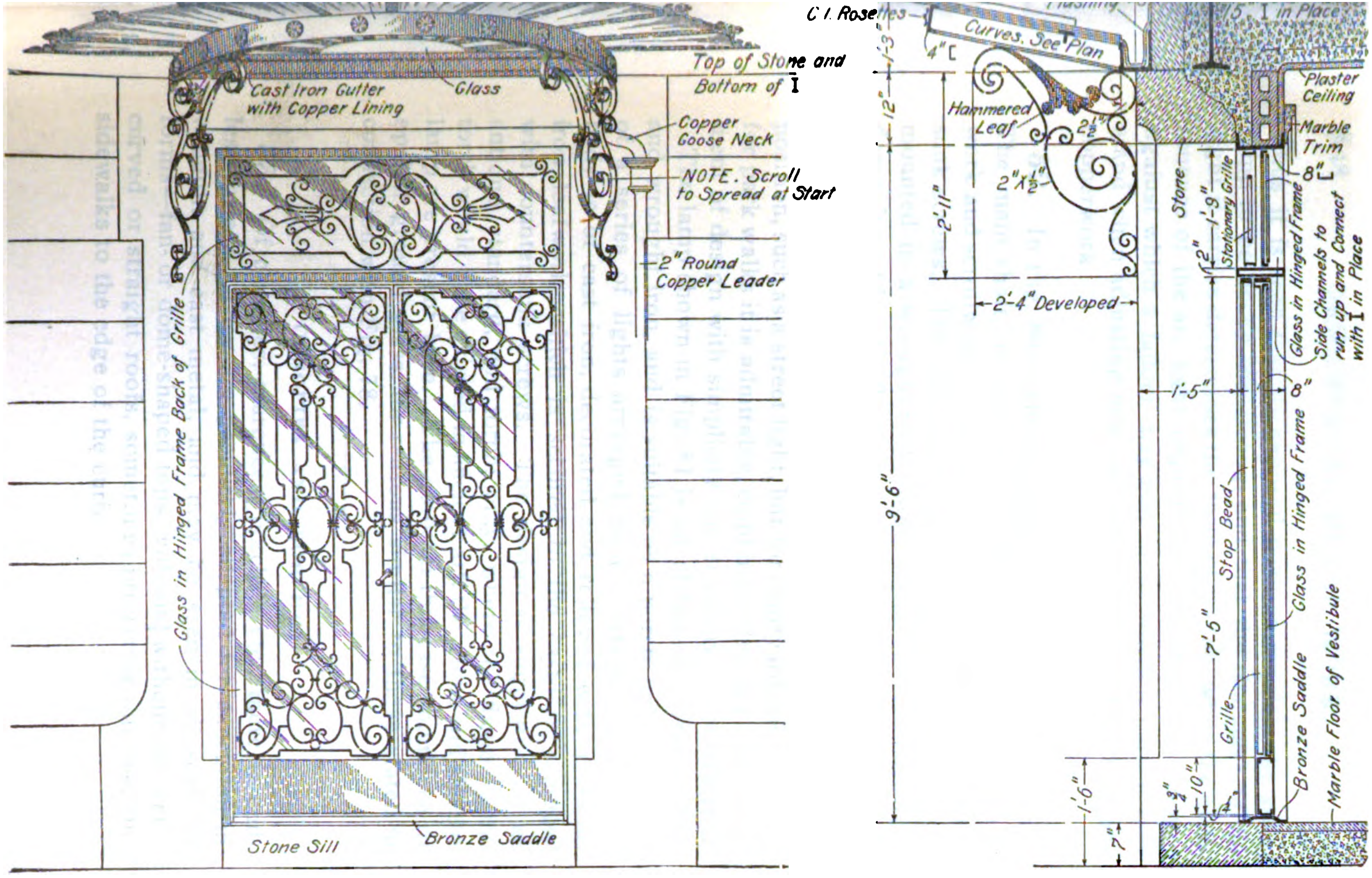
PLAN OF END



SECTION OF JAMB







FRONT ELEVATION

VERTICAL SECTION

Fig. 82

Thus it is seen that its exposed position requires the street lamp to be heavy and strong, and that the character of the light it carries determines the form of its top, while the maintenance of the arc light requires the two projecting rungs *a* against which a ladder may rest or on which a person may stand when adjusting new carbons or cleaning the globe and copperwork.

52. In Fig. 80 is shown a form of post for a gas lamp. The main shaft, or post, is of cast iron, on which the fretwork and scrollwork of wrought iron is secured with countersunk screws. The lantern at the top consists of glass plates mounted in a wrought-iron frame, which is covered with a dome-shaped hood. This lantern encloses the gas jet or jets and protects the flame from the wind. The scrollwork of this design is so delicate that it is hardly suited for a much exposed position, such as a street light, but for courtyards and lawns or for park walks it is admirable, combining delicacy and refinement of design with simplicity and economy of construction.

The lamp shown in Fig. 81 is an elaborate design in cast and wrought iron, and is suitable as a porch light or as one of a series of lights arranged in a courtyard. The main body is of cast iron, decorated and relieved with wrought-iron leafwork, which is secured to the cast-iron standard with countersunk screws. The design is suggestive of an antique, standard, and torch; only, where the flame of the torch would have existed in ancient art, the globe and electric lamp are present here. The globe in this case should be of opal or ground glass, for reasons similar to those stated in connection with Fig. 78.

CANOPIES AND PORCHES

53. Of canopies, marquees, porches, etc., there is endless variety. They are peculiarly adapted for execution in wrought and cast metal, and may be seen in all sorts of forms—fan- or dome-shaped tops, with and without brackets, curved or straight roofs, sometimes projecting out over the sidewalks to the edge of the curb.

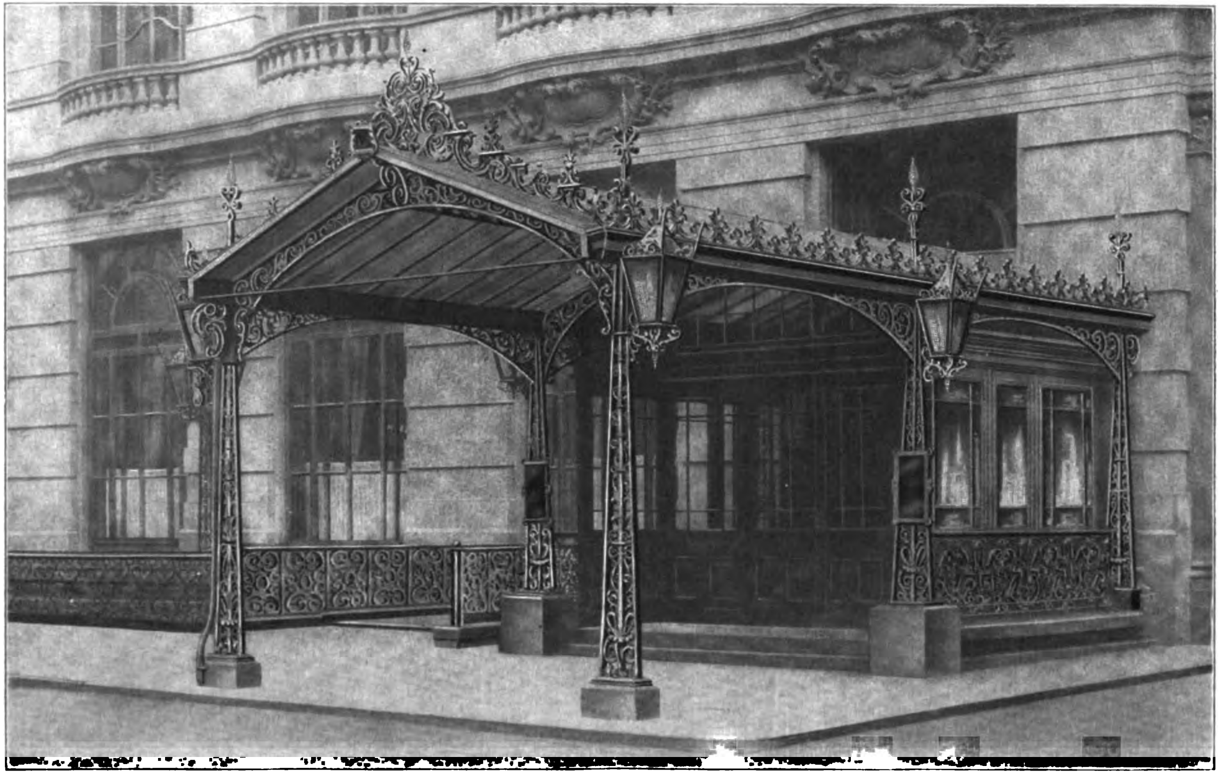


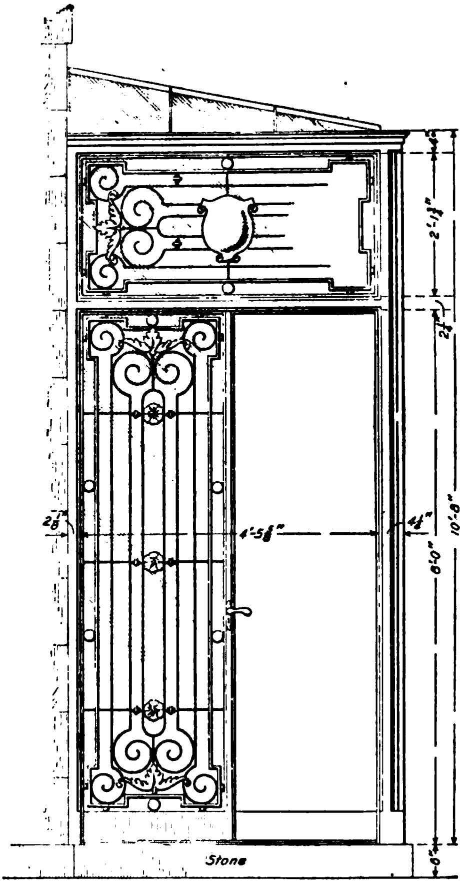
FIG. 83

An example of a fan design (this type is usually called a marquee) is given in Fig. 82 and it is only necessary to study the drawing in order to understand fully the construction. This style of canopy has rather a graceful effect over an entrance to a residence. As will be seen, it tilts back toward the wall, where the water is carried off by a copper gutter leading into a vertical pipe. The entrance doorway shown in the same drawing is similar to Fig. 84 and is built up in the same way.

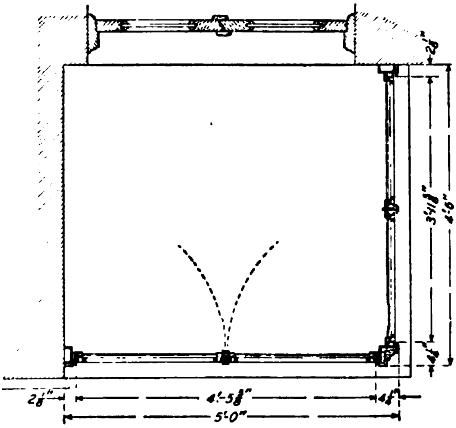
54. Fig. 83 is a carriage porch and entranceway built of wrought iron. The supporting columns spread out toward the bottom, giving an impression of strength as well as lightness. Branching from the columns on each side of the porch are lanterns of appropriate design. The roof of ribbed glass is supported by trusses of graceful design, while it is also furnished along the sides and over the front of the peak with crestings and terminals. In addition to being an important part of the architectural scheme, this porch as a whole forms a protection from sun or rain.

55. Somewhat similar to the porch just mentioned, but differing in that it is rather a vestibule, is the structure shown in Fig. 84 (*a*), (*b*), (*c*), (*d*). This vestibule is built in the angle of the building in front of the entrance. As far as the metal parts are concerned, it consists of the front, side, and roof, as can be seen from the plan in Fig. 84 (*b*). The detail sections in Fig. 84 (*c*) and Fig. 84 (*d*) show the construction of the enclosure.

The principal framing consists of 3-inch vertical channels placed next to the walls, a 3″ × 3″ angle at the corner, and an intermediate 2″ × $\frac{1}{2}$″ molded **T** bar in the middle of the side, dividing it into two panels corresponding to the design of the front. The bottom ends of these uprights are fastened to the stonework with expansion bolts or calked into holes in stonework. At the top, they are bolted to the cast-iron cornice or gutter, the ends of the cornice being embedded and calked in the stonework of the building. All of the exterior lines of the gutter are of course horizontal,



Front Elevation
(a)



(b)

Fig. 84 (a), (b)

but the inner surface of the bottom should be made slightly inclined throughout its whole length back toward the wall of the house. This will allow rain water to run off to a point where it is conducted by a pipe to the ground, either on the outside or inside of the wall. If the gutter is lined with copper, as is sometimes done, the fall can be formed in the lining.

The doors and side are glazed with clear plate glass behind the grille-work, and in order that the glass may be accessible for cleaning, the grille panels are hinged. If it is preferred, the grilles may be fixed and the glass panels hinged. The frames of the doors are made of $1\frac{1}{2}'' \times \frac{7}{8}''$ and $1\frac{1}{2}'' \times \frac{3}{4}''$ flat bars, to which is screwed the square rabbets. The glass is placed against these rabbets and is held in position by the flat bar corresponding to what would ordinarily be the stop-bead. In case the glass becomes broken, this flat bar is easily unscrewed and the glass replaced. The bars and scrollwork are made of $\frac{5}{8}'' \times \frac{1}{2}''$ and $\frac{5}{8}'' \times \frac{3}{8}''$ material. The

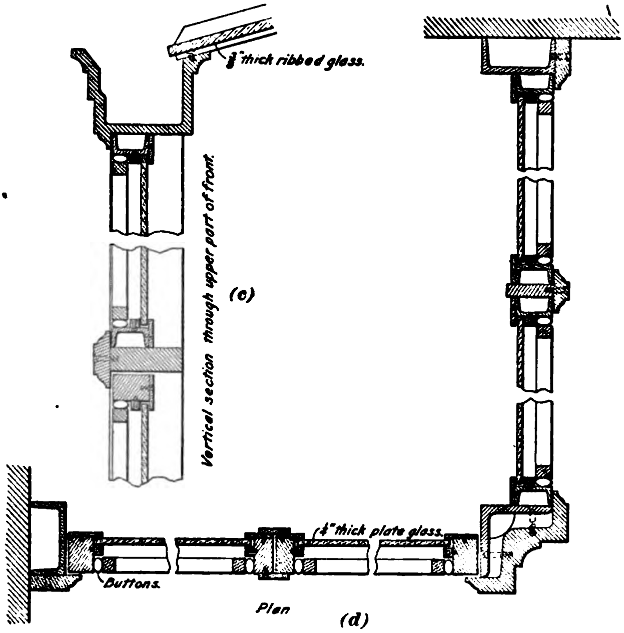


FIG. 84 (c), (d)

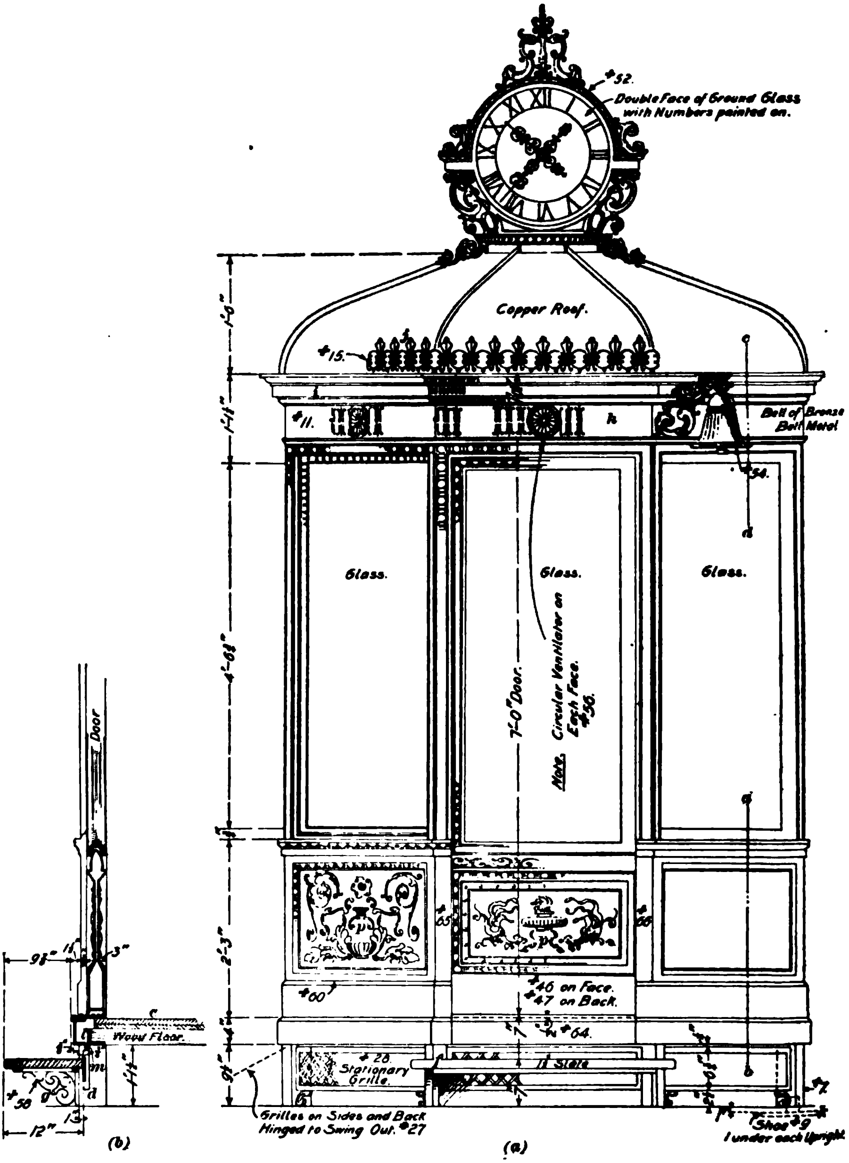
#52.
Double Face of Ground Glass with Numbers painted on.
Copper Roof.
#15.
#11.
h
Bell of Bronze Bell Metal
#54.
c
d
Glass.
Glass.
Glass.
7'-0" Door.
Note. Circular Ventilator on Each Face. #56.
1'-0"
1'-1½"
4'-6⅜"
2'-3"
9½"
#65
#66
#60
#46 on Face.
#47 on Back.
#64.
#28 Stationary Grille.
Slate
Grilles on Sides and Back Hinged to Swing Out. #27
Shoe #9
1 under each Upright
#7
a
b
p
Door
9½"
1½"
3"
12"
13
Wood Floor.
e
f
g
m
d
#58
(b)
(a)

FIG. 85

side and transom panels are very similar to the doors, except that the frame, being stationary, is fitted close against the main bars, and is formed of channels instead of solid metal. The cast-iron moldings and trim are added to give finish to the structural parts. The roof is composed of 1¼-inch **T**'s set about 1½ feet apart and is glazed with ribbed glass ⅜ inch thick, thus completing the structure.

The details of the pivots and lock for the doors are not shown. They should be drawn full size and arranged to suit conditions.

As a matter of practice, it would be well for the student to design a similar porch, changing the dimensions and sizes of material.

IRON STRUCTURES

56. It is sometimes desirable to erect small structures entirely of cast and wrought iron. Of these, the most common are the small domes or cupolas crowning the roofs of certain classes of buildings, and occasionally small detached buildings used as offices for the sale of tickets at the entrance of places of amusement, or as an adjunct to some branch of a general service system, as is the example hereafter shown. In any case, the structure is necessarily of an ornamental character, and must accord in design with surrounding conditions.

An example of a detached iron structure is shown in Fig. 85. The entire edifice is constructed of cast- and wrought-iron framework carrying a copper roof and heavy plate-glass window lights. The purpose of the building is that of a cab office in connection with the service of a hotel, club, or theater. The plan is octagonal, as shown in Fig. 86, each angle of the octagon being marked by a hollow cast-iron upright, molded to form the architraves of the window and door openings, and at the same time to contain the **T**-iron supports *d* of the roof and superstructure. These supports extend to the ground in each case, and stand on an iron plate, or shoe, as shown at *g* in the elevation, Fig. 85 (*a*), and between them is framed an angle iron, to

receive the ends of the floorbeams, as shown at *l* in the section, Fig. 85 (*b*). The space from this angle to the ground is filled with an iron grille, as shown in the elevation at *e*, while from the floor to the window level a cast-iron plate encloses each side of the octagon with an ornamental panel *p*.

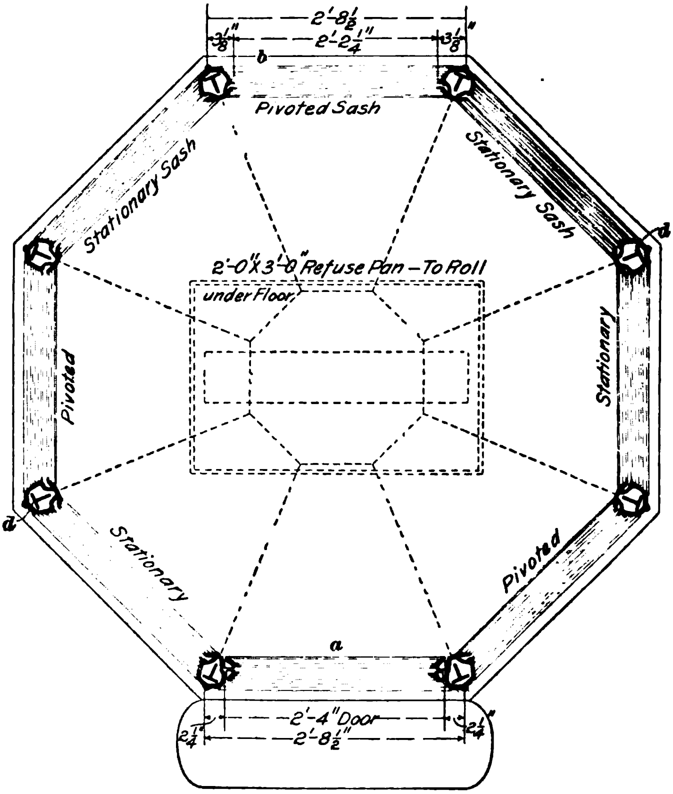


FIG. 86

The construction of this paneled dado can be better understood from Fig. 87, which is a section taken on the line *a b*, Fig. 85 (*a*). The angle iron framed between the vertical **T**'s, as shown at *l*, Fig. 85 (*b*), is here seen in section as piece *# 32*, and outside of it is the cast-iron facing of the structure, consisting of a water-table 4 inches in height, and the plinth,

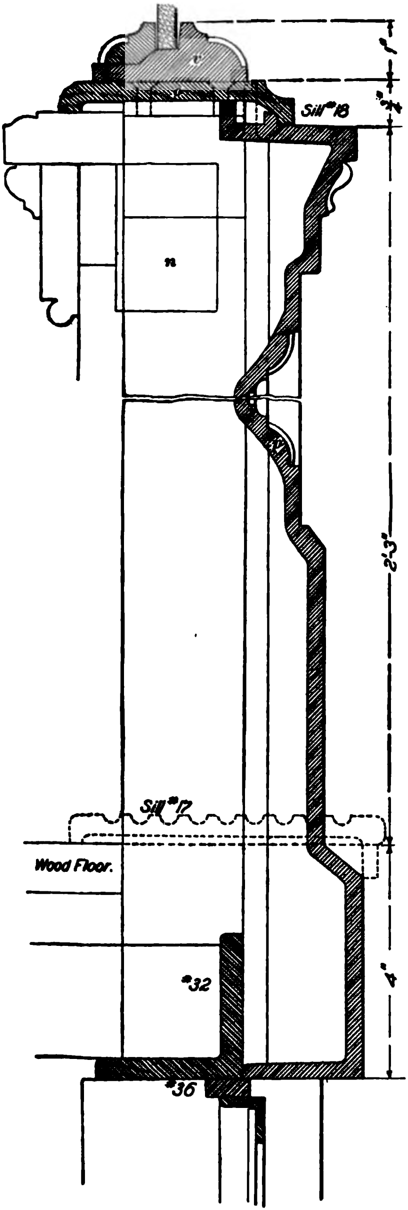


FIG. 87

panel, and window sill extending 2 feet 3 inches more. The sill cap *o* is secured at each end to angle-iron knees or brackets previously riveted or bolted to the vertical **T** supports. These sill caps extend over the top of the panel pieces and hold the latter in place by clamping over a rib piece cast on the top of the main panel, the panel pieces being fastened to the **T** supports by screw bolts. On this sill piece *o* rests the sash as shown at *v*, and on the inside of the office is secured the wood trim that forms the finish under the sill.

57. In Fig. 88 is shown a section through the cornice on the line *c d*, Fig. 85 (*a*). This cast-iron cornice is fastened at each end to the **T**-iron uprights with screw bolts, and thereby braces and secures these uprights at the top. The inside cornice *r* is secured in place by means of the wrought-iron strap *s* bolted to the main cornice, and to which the inside cornice is fastened with screw bolts. Observe that these screw bolts do not pass through the sash head, but simply secure the two pieces of cast-iron cornice to the strap or bar *s*, as this sash is to be pivoted (see plan).

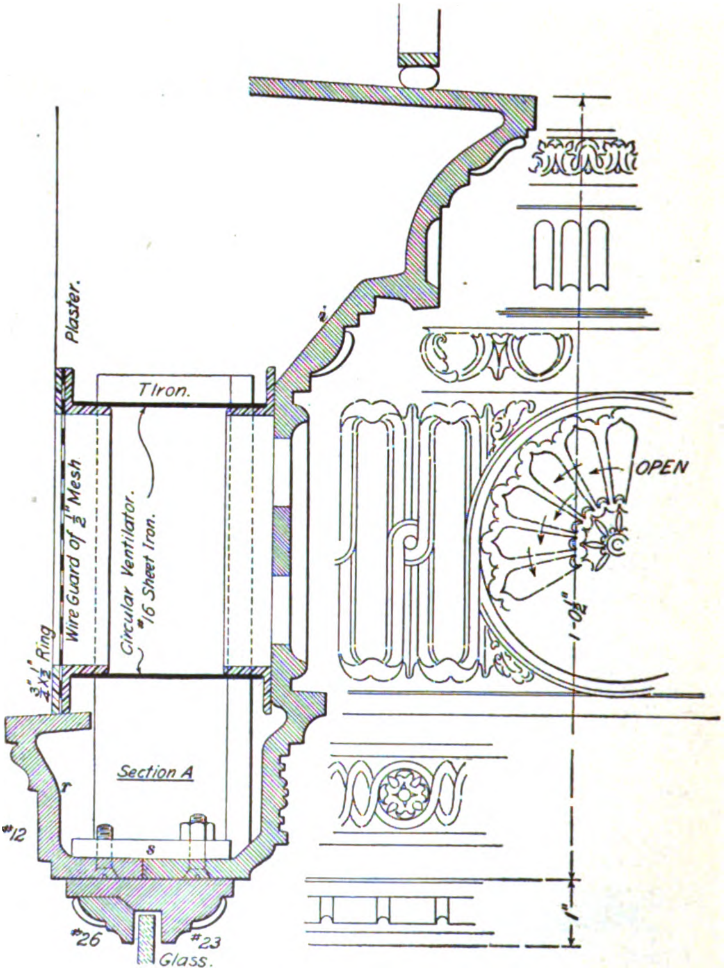


Fig. 88

In Fig. 89 (*b*) is shown a section through the lower part of the cornice where the sash is intended to be stationary (see plan). The inside or lining strap *s*, Fig. 88, is omitted in this case, and the outside cornice secures the top of the sash with a round-headed screw bolt, while the inside cornice is fastened to the sash head by a countersunk screw bolt, the sash head serving the same purpose here as did the strap piece *s* in Fig. 88. At the door opening, the lower fillet of the inside cornice is omitted, thus permitting the outside cornice to fall below it and form a stop, for the top of the door, as shown in Fig. 89 (*a*). An inside strap or bar *s* is then used to screw these cornices to, for the preservation of their alinement, while the ribs *t* cast on the

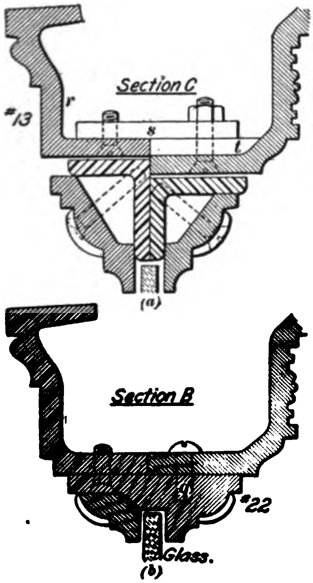


FIG. 89

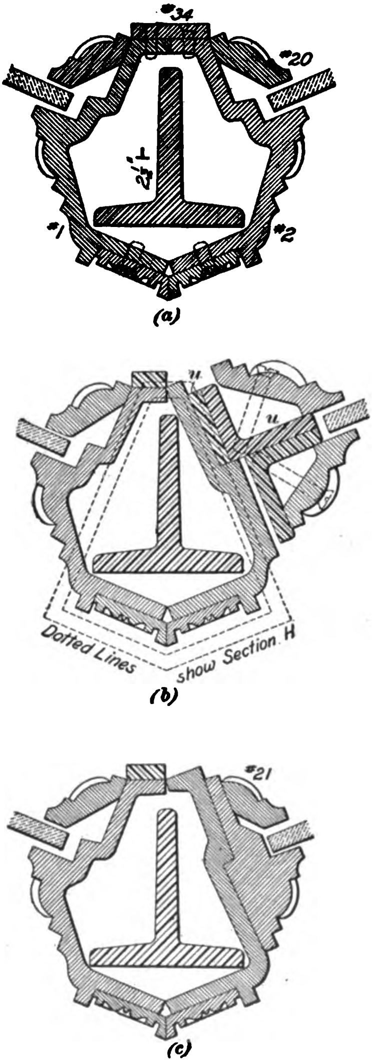


FIG. 90

exterior cornice maintain it in its proper position as a door stop.

58. The door frame is formed of two angle irons, whose legs are unequal, as shown in Fig. 89 (*a*). This inequality permits the inside angle to extend beyond the exterior one and strike (when the door is closed) against the door stop formed in the architrave or jamb casting.

Fig. 90 shows three sections through the architraves and supporting **T** irons of the main frame. At (*a*) is shown a section through the architraves of the fixed sashes, where the glass of the windows is held in place by a molding and recessions in the casting. At (*b*), the section shown is through the architrave at one side of the door, where provision is made in the casting for the door stop against which the longer-legged angle iron of the door frame shall strike; and at (*c*) is shown a section through the architrave at the side of a pivoted window sash. The glass is here shown secured in the cast-iron sash frame similar to that in Fig. 88, except that in this case a rabbet is cast in the frame and jamb against which the sash may strike when closed, and thus be prevented from revolving past the architrave.

59. The roof is framed with light angle irons bent to the form shown in the elevation, Fig. 85, and covered with copper on the outside, while the inside or ceiling is plastered on wire lath. The cresting around the eaves is of strap iron, the design being simple but neat, a detail of which is shown in Fig. 91. The clock face is framed in a cast-iron ring with ornamental scrolls as shown, the details being similar to other cast-iron ornament of this character heretofore described.

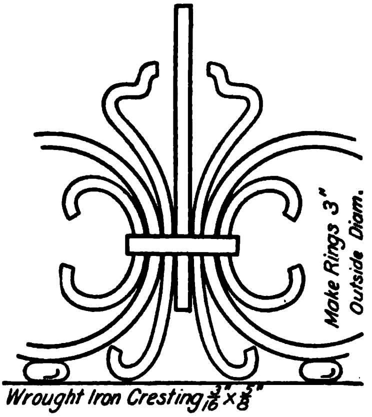


FIG. 91

60. It is hardly necessary to reiterate that the more one knows of the characteristics of the material and the methods of manufacture, the easier it will be to originate appropriate designs. There are many very interesting and curious ways of solving the difficulties of molding and patternmaking that cannot be explained at length here. The explanations given cover the subject sufficiently for the present purpose.

BUILDERS' HARDWARE

STAPLE HARDWARE

INTRODUCTION

1. The hardware used in building construction may be classified as *staple* and *finished*. **Staple hardware** may be considered as including such materials as nails and spikes, bolts and screws, sash weights, and other materials of this character, while **finished hardware** may include such devices and appliances as locks and latches, hinges, door and window trimmings, and the various metallic fixtures used in equipping the different classes of buildings. To this last classification the term *builders' hardware* is frequently applied.

Strictly speaking, glass cannot be considered as hardware; nevertheless, it is frequently supplied to the builder through hardware supply houses, and it is so closely allied to the hardware of building construction that the subject of glass, its trade terms, and other information relating to its characteristics, will not be out of order in this Section.

While little consideration is given to the hardware on the average building, there is no more important part of the construction, nor one to which greater attention should be given. On the quality and the selection of proper hardware depends the avoidance of the petty annoyances often found

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in buildings where this subject has not received proper consideration.

The architect should be well informed regarding this subject, and should be in a position to know the kind and quality of hardware that, when specified, will give the best results. He will find that a thorough knowledge of builders' hardware will assist him materially in writing comprehensive specifications for this portion of the work. Consequently, the writing of the hardware specifications will receive attention in this Section, and the proper manner of estimating, or "taking off," hardware will also be considered.

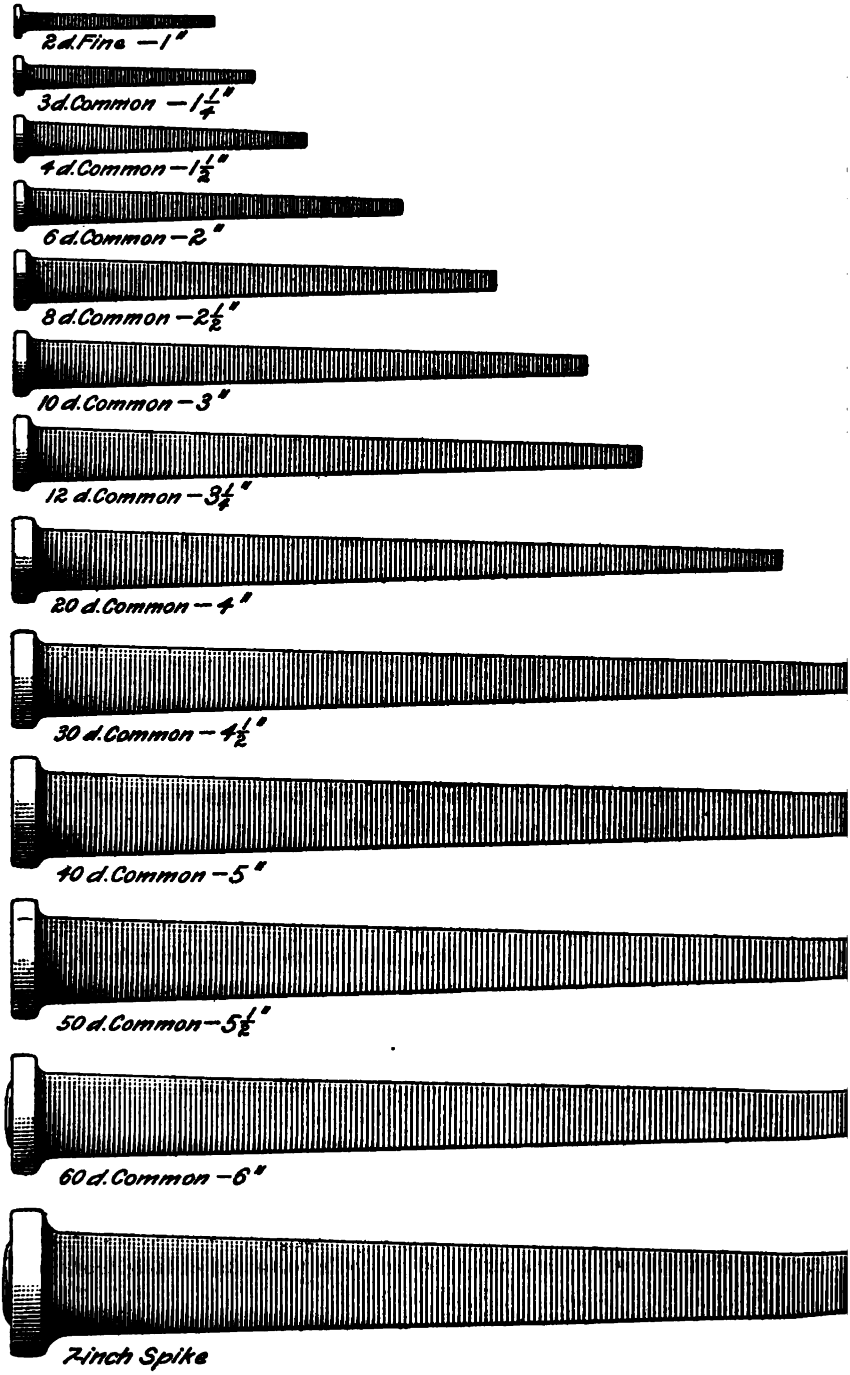
CUT AND WIRE NAILS

2. Cut Nails.—The primitive nail was made or forged by hand, and this mode of manufacture still exists in certain sections of Europe. These hand-made nails sold at exorbitant prices compared with the machine-made nails of today.

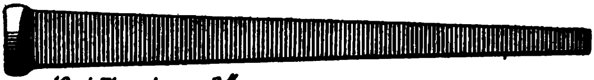
The manufacture of cut nails is less automatic and requires more manual labor than is necessary in the making of wire nails. The iron or steel is first rolled into sheets, the thickness of which is equal to the thickness of the nail; it is then cut into strips as wide as the nail is long. This strip of metal is fed into the nail machine and sheared off in tapering strips having the form of the nail, when it is seized by clamps that hold it just long enough for the heading hammer to strike the blow that forms the head.

The nail manufactured in this manner is known as the **cut nail**, and is much superior to the wire nail, which is of more recent production. Not only has the cut nail greater holding power, but it is more durable, especially when used in damp places.

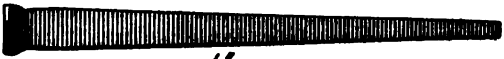
3. Nearly all cut nails used at the present time are made from sheet steel, a small percentage only being manufactured of iron, for which the makers charge a slightly higher price. The steel nail is undoubtedly the best for use in hardwoods,


2d.Fine —1"
3d.Common —1¼"
4d.Common—1½"
6d.Common—2"
8d.Common —2½"
10d.Common—3"
12 d.Common —3¼"
20 d.Common — 4"
30 d.Common — 4½"
40 d.Common —5"
50 d.Common—5½"
60 d.Common —6"
7inch Spike

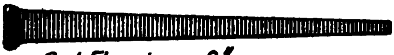
Fi



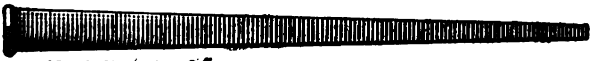
10 d. Flooring – 3"



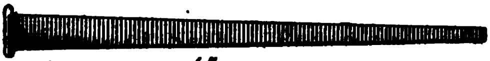
8 d. Flooring – 2½"



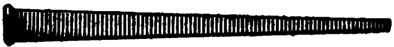
6 d. Flooring – 2"



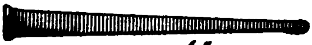
10 d. Finish – 3"



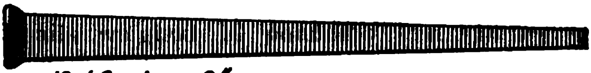
8 d. Finish – 2½"



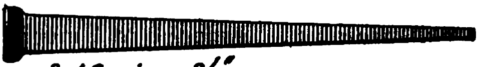
6 d. Finish – 2"



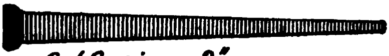
4 d. Finish – 1½"



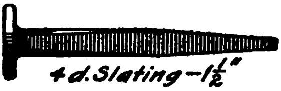
10 d. Casing – 3"



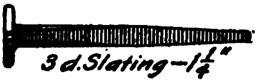
8 d. Casing – 2½"



6 d. Casing – 2"



4 d. Slating – 1½"



3 d. Slating – 1¼"

1

but the iron nail will outlast it where dampness exists, as, for instance, in shingling, etc.

As shown in Fig. 1, cut nails are made in many styles and sizes, and for various purposes. They are also known by the same trade term for the various styles. Cut nails are heavier than wire nails, and as they count fewer to the pound, are more expensive at equivalent prices. All nails are sold at base prices per keg of 100 pounds, the "extras" for smaller and special nails being added to the base price. For special work, certain types of nails can be obtained in copper and brass.

4. Size and Gauge of Nails.—Both cut and wire nails are designated by the trade term *penny*. The term penny as applied to nails is a relic of medieval England. This designation was due, it is said, to the fact that it defined the *cost per hundred nails*, so that *tenpenny nails* would mean that 100 of such nails cost *ten pence*. A more likely interpretation of the term is that it implied the *weight* and not the *cost*, and that the term penny is a corruption of the Old English word *pun'* (for pound), so that *tenpunny* or *tenpenny* implied that 1,000 of such nails weighed 10 pounds. The smallest standard size of nail is known as *twopenny* or *threepenny*, while the largest is designated as *sixtypenny*. These sizes range in length from 1 to 6 inches. In designating the size of the nail in list prices, the symbol "d" (for penny) is used, so that a nail about 2 inches long is designated as 6d. The thickness, or diameter, is indicated by the gauge number, the gauge of cut nails being an indication of the thickness of plate from which they are cut, while the gauge of wire nails is the size of the wire from which the nails are formed. The different wire gauges and their decimal equivalents of an inch are given in Table I. The special wire gauge commonly used to indicate the size of the nail is the Birmingham. In Table II is given a list of the stock sizes of standard, common, cut nails. This table, besides giving the thickness of the nail and its length, gives the number of nails to the pound.

TABLE I

STANDARD WIRE GAUGES AND THEIR DECIMAL EQUIVALENTS OF AN INCH

Number of Wire Gauge	American, or Brown & Sharpe	Birmingham	Washburn & Moen Manufacturing Company	Trenton Iron Company	United States Standard	Old English From Brass Manufacturers' Lists
000000			.4600		.46857	
00000			.4300	.4500	.43750	
0000	.460000	.454	.3930	.4000	.40625	
000	.409640	.425	.3620	.3600	.37500	
00	.364800	.380	.3310	.3300	.34375	
0	.324950	.340	.3070	.3050	.31250	
1	.289300	.300	.2830	.2850	.28125	
2	.257630	.284	.2630	.2650	.26563	
3	.229420	.259	.2440	.2450	.25000	
4	.204310	.238	.2250	.2250	.23438	
5	.181940	.220	.2070	.2050	.21875	
6	.162020	.203	.1920	.1900	.20313	
7	.144280	.180	.1770	.1750	.18750	
8	.128490	.165	.1620	.1600	.17188	
9	.114430	.148	.1480	.1450	.15625	
10	.101890	.134	.1350	.1300	.14063	
11	.090742	.120	.1200	.1175	.12500	

12	.080808	.109	.1050	.1050	.10938	
13	.071961	.095	.0920	.0925	.09375	
14	.064084	.083	.0800	.0800	.07813	.08300
15	.057068	.072	.0720	.0700	.07031	.07200
16	.050820	.065	.0630	.0610	.06250	.06500
17	.045257	.058	.0540	.0525	.05625	.05800
18	.040303	.049	.0470	.0450	.05000	.04900
19	.035390	.042	.0410	.0390	.04375	.04000
20	.031961	.035	.0350	.0340	.03750	.03500
21	.028462	.032	.0320	.0300	.03438	.03150
22	.025347	.028	.0280	.0270	.03125	.02950
23	.022571	.025	.0250	.0240	.02813	.02700
24	.020100	.022	.0230	.0215	.02500	.02500
25	.017900	.020	.0200	.0190	.02188	.02300
26	.015940	.018	.0180	.0180	.01875	.02150
27	.014195	.016	.0170	.0170	.01719	.01875
28	.012641	.014	.0160	.0160	.01563	.01650
29	.011257	.013	.0150	.0150	.01406	.01550
30	.010025	.012	.0140	.0140	.01250	.01375
31	.008928	.010	.0135	.0130	.01094	.01225
32	.007950	.009	.0130	.0120	.01016	.01125
33	.007080	.008	.0110	.0110	.00938	.01025
34	.006304	.007	.0100	.0100	.00853	.00950
35	.005614	.005	.0095	.0090	.00781	.00900

TABLE II

SIZE AND NUMBER TO THE POUND OF COMMON CUT NAILS

Trade Term	Length Inches	Gauge	Number to Pound
3d. fine	1 1/8	16	720
3d flat	1 1/4	15 full	430
4d flat	1 1/2	14 full	275
5d flat	1 3/4	13 regular	215
6d common	2	12 regular	150
7d common	2 1/4	11 light	120
8d common	2 1/2	11 regular	96
9d common	2 3/4	10 light	72
10d common	3	10 regular	64
12d common	3 1/4	9 regular	44
16d common	3 1/2	8 regular	32
20d common	4	7 regular	28
30d common	4 1/2	6 regular	18
40d common	5	5 regular	14
50d common	5 1/2	4 regular	12
60d common	6	3 regular	10

5. Wire Nails.—The term **wire nail** is applied to nails made from drawn wire, or wire rods. Since their introduction some years ago, wire nails have become decidedly popular, and in some localities are used in preference to the old-style cut nails, owing to the fact that there are a greater number to the pound, which makes them cheaper than cut nails at the same price per keg. The size and number of common wire nails to the pound are given in Table III. By comparing the columns in Tables II and III giving the number of nails to the pound for both cut and wire nails, it can be readily seen that the wire nails are greater in number for a given weight than cut nails of the same size. For this reason, the wire nails are used by contractors on cheap work.

Wire nails are more liable to rust than cut or wrought nails, and are consequently not so durable in damp situations; they also have less holding power and more must be used to obtain the same strength.

Common wire nails in sizes from twentypenny to sixtypenny are sold at base price, say $2 per keg, the smaller sizes costing an advance over the base price. Thus, an eightpenny common nail would cost 10 cents additional, or $2.10 per hundred pounds, while a twopenny nail would cost $2.70 per hundred pounds, etc. The present advance above the base price on 100-pound kegs for the several sizes is also given in this table. All wire nails can be procured "barbed" at an additional advance of 15 cents above base and extra prices.

TABLE III

SIZE AND NUMBER TO THE POUND OF COMMON WIRE NAILS

Size	Length Inches	Gauge Number	Approximate Number to the Pound	Advance Over Base Price per 100 Pounds
2d	1	15	876	$0.70
3d	1¼	14	568	.45
4d	1½	12½	316	.30
5d	1¾	12½	271	.30
6d	2	11½	181	.20
7d	2¼	11½	161	.20
8d	2½	10¼	106	.10
9d	2¾	10¼	96	.10
10d	3	9	69	.05
12d	3¼	9	63	.05
16d	3½	8	49	.05
20d	4	6	31	Base
30d	4½	5	24	Base
40d	5	4	18	Base
50d	5½	3	14	Base
60d	6	2	11	Base

The relative sizes of the common wire nail are best learned from samples of the same, but Fig. 2, which shows these nails full size, from sixtypenny to twopenny, clearly indicates their proportions.

6. Wire Nails for Special Purposes.—Wire nails as well as wrought or cut nails are made in a variety of forms especially suitable for the specific purpose for which they are intended. The several kinds of wire nails in common use are illustrated in Fig. 3.

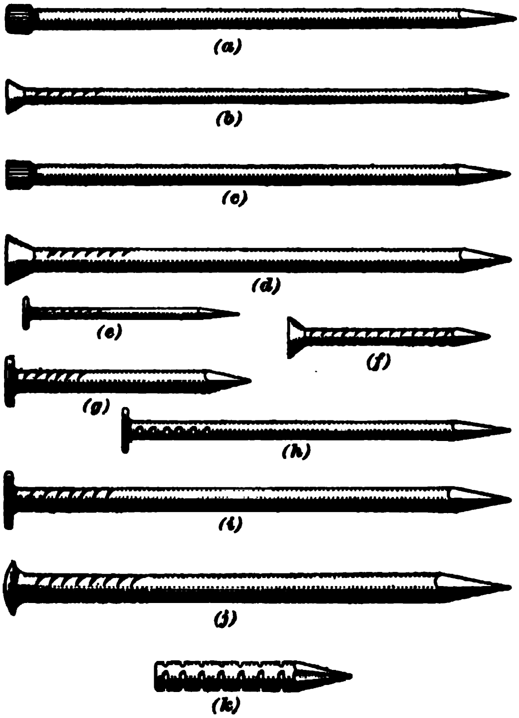
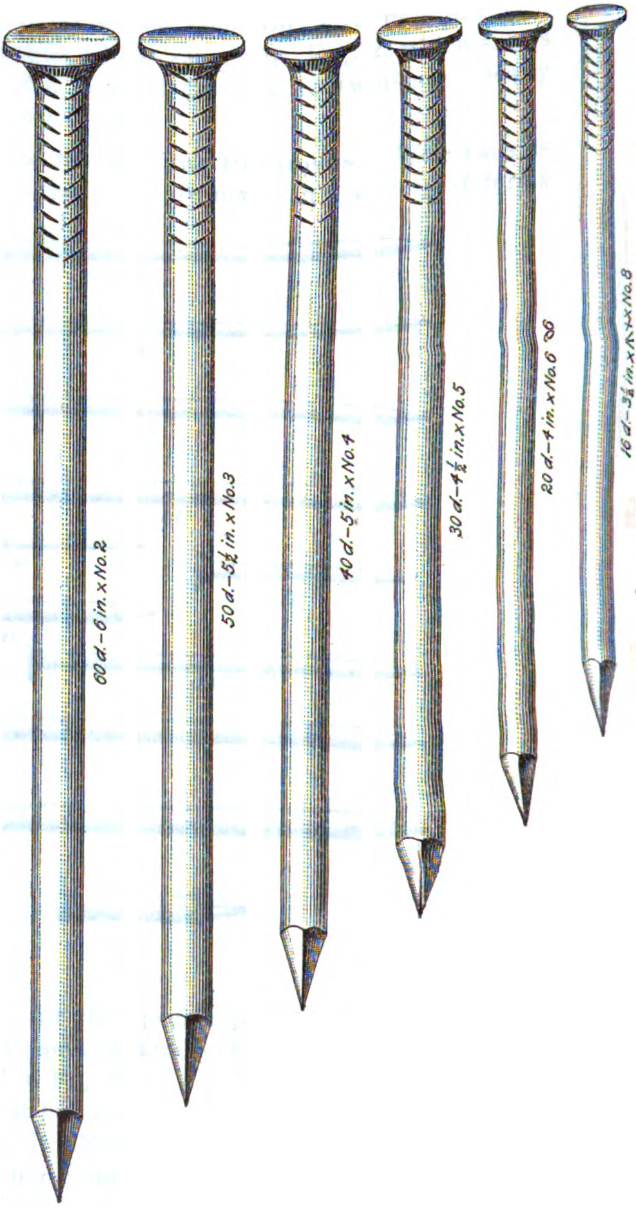
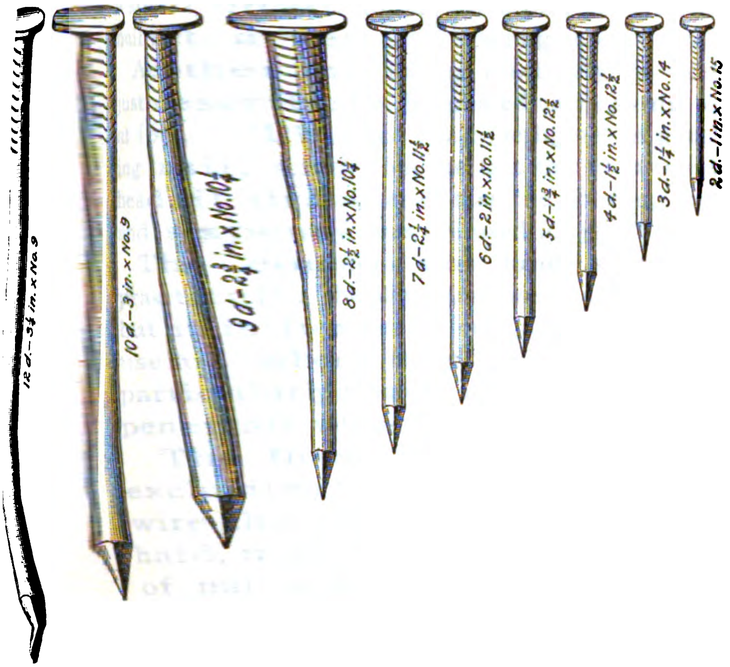


FIG. 3

A nail used about buildings for putting the trim, or finishing work, together is illustrated at (*a*), and from its use is known as a **finishing nail.** These nails are used almost exclusively for this purpose and are very light. They have



60 d.–6 in. x No. 2
50 d.–5½ in. x No. 3
40 d.–5 in. x No. 4
30 d.–4½ in. x No. 5
20 d.–4 in. x No. 6
16 d.–3½ in. x No. 8


12 d.–3¼ in. × No. 9
10 d.–3 in. × No. 9
9 d.–2¾ in. × No. 10¼
8 d.–2½ in. × No. 10¼
7 d.–2¼ in. × No. 11½
6 d.–2 in. × No. 11½
5 d.–1¾ in. × No. 12½
4 d.–1½ in. × No. 12½
3 d.–1¼ in. × No. 14
2 d.–1 in. × No. 15

a small head, so that when they are set into the wood with a nail set, a very small opening is left for puttying.

Another nail having practically the same use as the one just described is designated as a **casing nail**, and is shown at (*b*). This nail is a trifle lighter in gauge than the finishing nail, and from the fact that it is countersunk under the head, it draws better than the finishing nail. The fivepenny and sixpenny sizes are used for putting on siding.

The **common wire brad**, shown at (*c*), is used for practically the same purposes as the regular finishing nail, but it is from two to four gauges heavier. This wire brad is useful when a heavy nail with a small head is required, particularly in hardwood, where a light finishing nail will not penetrate without bending.

The **flooring brad**, shown at (*d*), is a nail used almost exclusively for flooring. This nail is made of heavier gauge wire than other nails of this type, and drives easily, even in hard, maple floor. The construction of the head of this type of nail allows for severe "drawing" without splitting the tongue of the flooring boards.

The **fine-wire nail**, shown at (*e*), commonly called a **lath nail**, is made in four sizes and is used for nailing lath to studding. Owing to its smoothness, cleanliness, and easy-driving qualities, this type of nail is extensively used.

A short, heavy nail, the whole length of which is barbed to increase its holding qualities, is shown at (*f*). This nail is known as a **barbed roofing nail**, and is generally used for nailing tin roofs and ready, or prepared, roofing of every description. It is also used with tin roofing caps.

At (*g*) is shown a **slating nail**. This type of nail is formed from heavy gauge wire, and has a flat head that is large in proportion to its length. This nail is used only for slating, but is not so durable as the cut nail made for this purpose. Nails of this kind are made in only five sizes.

A type of nail used for attaching wooden shingles, and known as the **shingle nail**, is shown at (*h*). This nail is seldom carried in stock, however, as threepenny and fourpenny common nails answer the purpose. These shingle nails are clean and easily driven, but are not so durable as cut nails.

A very heavy nail of the same character as the common wire nail, but made much heavier, in order to increase the holding qualities and to provide greater durability, is known as the **fence nail.** This nail is made as shown at (*i*).

At (*j*) is shown a **clinch nail** that is manufactured from soft wire or annealed hard wire. This nail answers the same purpose as the old-style wrought, or clinch-cut, nail commonly used in the construction of batten doors, etc. The metal being very soft at the end of the nail, allows the point to be bent and driven back into the wood to form the clinch. These nails do not differ from the common wire nail, except in the form of the head and the material from which they are made, as will be seen from Fig. 3 (*j*) and Fig. 2.

There is a form of headless wire nail, known as a **barbed dowel-pin,** which is made as shown in Fig. 3 (*k*). This type of nail, or dowel, is used for doweling through the mortises and tenons of sash, blinds, and frames of every description. In the mill, it has displaced the wooden dowel used in former times. The length of pin to be employed is regulated by the thickness of the wood to be secured, as the pins are used $\frac{1}{4}$ inch shorter than the thickness of the woodwork.

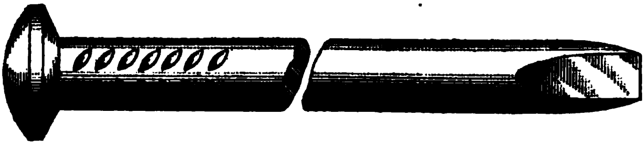


FIG. 4

An exceptionally heavy nail, or spike, is made from heavy wire or round bar. These spikes are used for heavy construction work, such as splined flooring, for slow-burning mill construction, and for bridge flooring. They are made with both chisel points, as shown in Fig. 4, and diamond points, and in ordering them, the kind of point, as well as the style of head wanted should be specified. Spikes of this kind are made in all sizes from tenpenny, which is of

No. 6 gauge and 3 inches long, to spikes ⅜ inch in diameter and 12 inches long.

7. Galvanized Nails and Spikes.—Nails and spikes, either cut or wire, that have been dipped into molten zinc and become coated with this metal are termed **galvanized.** By this process they are rendered practically rust-proof. Cut or wire galvanized nails can be obtained in the same sizes and types as ordinary nails, and if dealers do not regularly carry them in stock, they will as a rule have them galvanized to order. In order to secure durability, it is advisable to use galvanized nails in places that are exposed to dampness, as in shingling, in slating, in fence building, or in structures erected near the seashore, as it has been proved by numerous tests that ordinary nails rust through in such places in a few years. The galvanized nails cost from $1.50 to $3 more per keg than the plain cut or wire nails.

The cheaper grades of galvanized nails are frequently coated only with lead, and will not withstand the government test; that is, dipping them into vitriol. A simple way to test the coating of a galvanized nail is to rub the nail on a piece of white paper. A lead-coated nail will mark the paper the same as a lead pencil and should be rejected, as it is only a sham and has no redeeming qualities.

WOOD SCREWS, EXPANSION AND SPECIAL BOLTS

8. Wood Screws.—The ordinary **wood screw,** which is one of the staple articles of hardware, is very necessary in the application of all builders' hardware about the building. Except in some lines of cheap or rough, unfinished goods, hardware manufacturers now pack with all hardware, screws that match the finish of the goods. The various types of screws now on the market are illustrated in Fig. 5, and the common types, such as flat-, round-, oval-, and fillister-headed screws are easily procured.

Iron screws are made with either flat, round, or oval heads and the following finishes: Bright, blued, japanned, tinned, galvanized, bronze-plated, brass-plated, coppered, silvered, and nickel-plated. Brass and bronze metal screws can also be procured with flat, round, or oval heads, in either natural color or, on special order, finished to match the hardware.

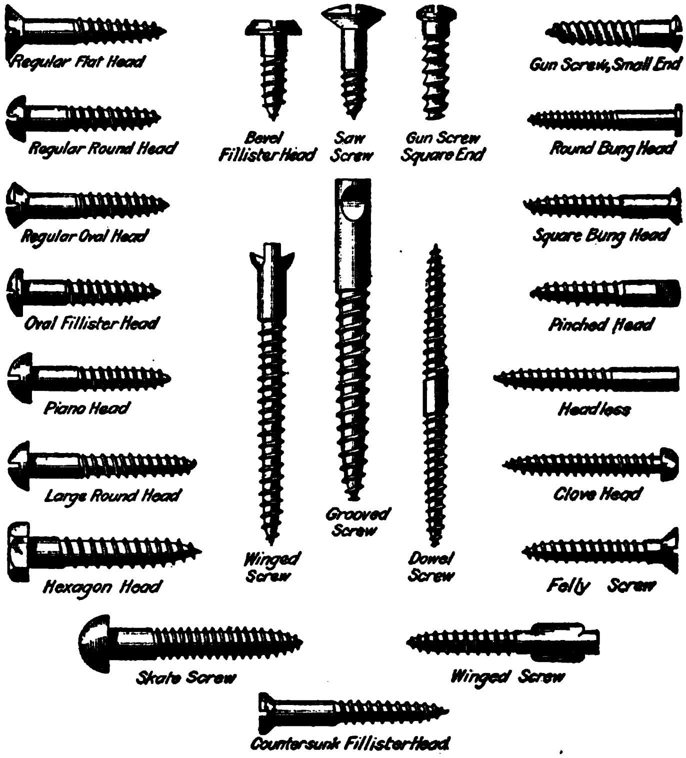


FIG. 5

Special screws are also manufactured for various purposes, which are sufficiently explained by the illustration, Fig. 5.

Screws are always measured for length from the point to the top of the head. The sizes in which screws can be obtained are given in Table IV. The diameter of screws is always measured directly under the head, and is always given in numbers of the screw makers' gauge. The numbers vary from 0 to 30, going consecutively without skip from 0 to 18 and from then on using only the even numbers. In Table IV are also given the numbers of the screw makers' gauge and their equivalents in decimals of an inch.

TABLE IV

SIZE OF WOOD SCREWS

Length Inches	Diameter in Screw Makers' Gauge	Length Inches	Diameter in Screw Makers' Gauge
1/4	From 0 to 4 inclusive	2	From 5 to 24 inclusive
3/8	From 0 to 9 inclusive	2 1/4	From 5 to 24 inclusive
1/2	From 1 to 12 inclusive	2 1/2	From 5 to 24 inclusive
5/8	From 1 to 14 inclusive	2 3/4	From 6 to 24 inclusive
3/4	From 2 to 16 inclusive	3	From 6 to 26 inclusive
7/8	From 2 to 16 inclusive	3 1/2	From 8 to 26 inclusive
1	From 3 to 20 inclusive	4	From 8 to 30 inclusive
1 1/4	From 3 to 24 inclusive	4 1/2	From 12 to 30 inclusive
1 1/2	From 3 to 24 inclusive	5	From 12 to 30 inclusive
1 3/4	From 5 to 24 inclusive	6	From 12 to 30 inclusive

SCREW MAKERS' GAUGE

Number of Screw Gauge	Equivalent in Decimals of an Inch	Number of Screw Gauge	Equivalent in Decimals of an Inch
0	.05784	13	.22892
1	.07100	14	.24208
2	.08416	15	.25524
3	.09732	16	.26840
4	.11048	17	.28156
5	.12364	18	.29472
6	.13680	20	.32104
7	.14996	22	.34736
8	.16312	24	.37368
9	.17628	26	.40000
10	.18944	28	.42632
11	.20260	30	.45264
12	.21576		

9. Drive Screws.—A screw known as the **drive screw** is used mostly in the manufacture of various articles where cost is the controlling factor. These screws, shown in

Fig. 6, are made somewhat on the order of the wood screw, but without the deep-cut thread and gimlet point. Screws of this type are driven into the wood with a hammer and have slotted heads so that they may be withdrawn by means of a screwdriver. The thread is so constructed that the wood may be penetrated without breaking down its fiber when the screws are driven, and is shaped so as to engage with the wood while resisting a pulling stress. These screws are made with flat, round, or oval heads, as illustrated respectively at (*a*), (*b*), and (*c*), and may be had in sizes from ½ inch to 4 inches in length.

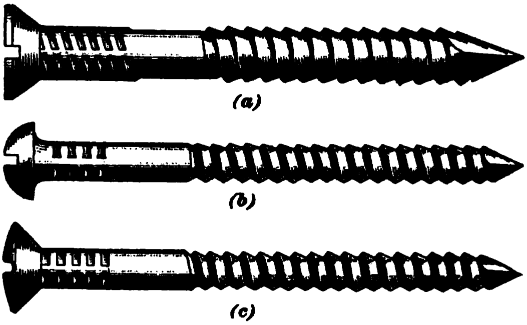
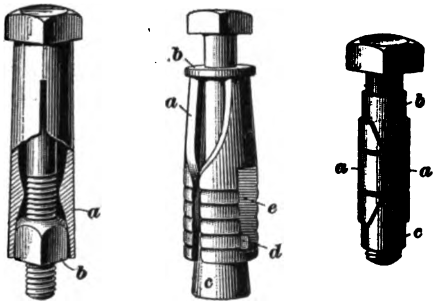


FIG. 6

10. Expansion Bolts.—The **expansion bolt** is a device that has proved extremely valuable in the building trades, as it provides a means of bolting to stone, brick, concrete, slate, or other materials of this nature. Expansion bolts are used principally in places where it is not desirable or practicable to drill through the material to which the fastenings are to be made. This type of bolt has also a great advantage over other fastenings in that it can be removed with as much ease and facility as it is applied, and also without injury either to the article fastened or the material to which it is fixed, the bolt likewise sustaining no injury.

Many styles of expansion bolts are now manufactured under various patents, and these may be procured in all sizes and made of iron, steel, or brass.

In Fig. 7 are shown several makes of expansion bolts. The *McCabe expansion bolt*, shown at (*a*), is constructed of a malleable, cylindrical-shaped, slotted case, or shell, *a*, the aperture of which reduces in size and engages with a bevel-shaped hexagon nut *b*. By turning the bolt, the nut is drawn toward the head and thus expands the outer case in its passage; this in turn binds against the sides of the hole in the masonry into which the bolt is inserted. The shell, as the outside case *a* is called, can be procured in any length or diameter, and can be used with any machine bolt having a standard thread. The McCabe bolt is suitable for bolting any thickness of material, provided the proper length of bolt is employed.



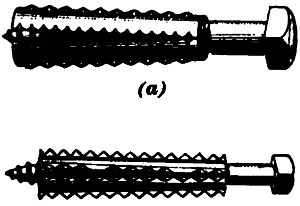
(a) (b) (c)

FIG. 7

The *Brohard expansion bolt* shown at (*b*), performs the same functions as the bolt illustrated at (*a*). The case, or shell, *a*, is composed of two or more parts riveted to a wrought circular plate, near the head, as at *b*. These several parts are expanded by means of the beveled nut, which approaches the head as the bolt is turned. The principal feature of the Brohard expansion bolt is that the beveled nut *c* cannot be forced from the case on account of the lug *d*, which is attached to the nut and travels in the slot *e* when the bolt is turned.

The *Steward and Romaine double-expansion bolt* is shown at (*c*). The shell of this bolt is composed of two semicylindrical parts, as at *a*, *a*, that are somewhat longer in diameter than the wedge-shaped nut and the sleeve at *b* and *c*, respectively. Each half of the shell is held in place by light rubber bands. The wedge-shaped parts are caused to approach each other by the turning of the bolt, and thereby expand the split case at both ends simultaneously. From the fact that this bolt is expanded at both ends, it is called a **double-expansion bolt,** although it may be made single-expansion by omitting the wedge-shaped sleeve at the head.

The *Star expansion bolt*, shown in Fig. 8 (*a*), performs exactly the same duty as other expansion bolts, but its construction is radically different. This bolt consists of only two parts, called *shields*. Each shield is semicircular in form and interlocks at the joints. The exterior of these shields has four rows of corrugated ridges, or star-shaped projections, that prevent the shields from turning in the hole. The interior of the shell is threaded and decreases in size toward the farther end. Thus, by inserting a lag, or coach, screw of any length, so as to engage with the thread, the shields are spread apart at the farther end while the screw is entering the aperture.


(a)

(b)

FIG. 8

The *Diamond expansion bolt* shown at (*b*) is practically the same as the one just described, as will be observed from the figure.

Expansion bolts are also made with all the parts entirely of brass or bronze, with either plain, capped, or fancy heads, or nuts, and in any finish desired.

11. Screw Anchors.—The device known as a *screw anchor* can be used in place of an expansion bolt for securing light materials. Several kinds of screw anchors are in the market at present. The *star anchor*, which is made in one piece of composition metal that is slotted about seven-eighths of its length, may be obtained in various diameters and lengths. The exterior has two star-like projections, to prevent the anchor from turning, while the interior is constructed of ridges projecting from the tube, with the hole reduced toward the slotted end. This internal construction permits the star anchor to be used in combination with trade wood or machine screws of any length. The screw used engages with the ridges in the interior, cutting its own thread and expanding the anchor in its passage. These composition anchors are very cheap, the price ranging from 1 to 3 cents, according to the size. They are made in different lengths, from ½ inch to 1½ inches, and for Nos. 6, 10, 14, and 18 wood screws.

12. Special Bolts.—In Fig. 9 is shown a **toggle bolt.** This device is a recent production for fastening materials to surfaces having a hollow interior that will not admit the use of expansion or tap bolts because of its frail character, as, for instance, sheet metal, hollow fireproofing, etc. The toggle bolt shown in the figure is constructed with long, fine-pitch threads cut nearly to the head, so as to allow for securing thin materials. The T-shaped head *a* is constructed either hollow, as shown in the figure, or of flat strip metal, and is riveted loosely to the end of the bolt, allowing the head to pivot and fold over the bolt, and thus permitting the head to pass through a small opening. The head is then tipped into its proper position, when the bolt is ready for securing in place the work to be fastened. The construction of the bolt is shown in Fig. 9 (*a*), while the process of affixing it is illustrated at (*b*) and (*c*). These toggle bolts are generally made with 3/16-, ¼-, and 5/16-inch bolts, from 2½ to 6 inches long, and of either iron, steel, or brass.

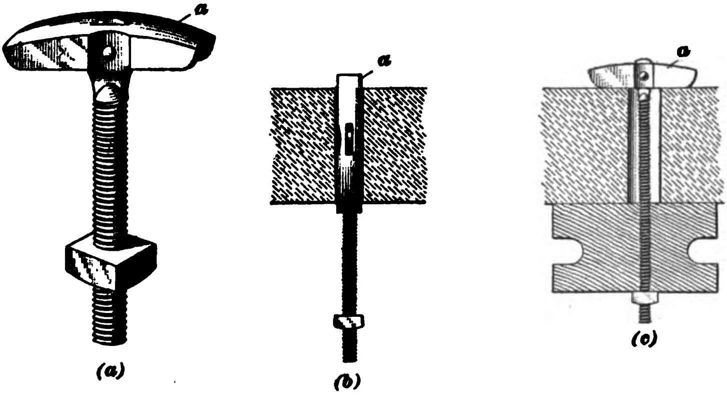


FIG. 9

SASH WEIGHTS

13. Cast-Iron Weights.—The term **sash weight** is applied to a counterweight used for balancing double-hung, or sliding, sash. These weights are generally very rough, being made from either the poorest iron or waste iron. The stock sizes are usually long and cylindrical in form—from 1⅜ to 2¼ inches in diameter—have an eye cast in the upper end, as shown in Fig. 10, and weigh from 2 to 30 pounds, the weight determining the length of the sash weight. In Table V are given the weight, diameter, and length of sash weights as they are generally furnished to the trade, although it is almost impossible to give this data with any degree of accuracy, as the different manufacturers vary the diameters of the weights slightly, and this changes the length measurement. Square weights or special weights can be easily procured at small additional cost.

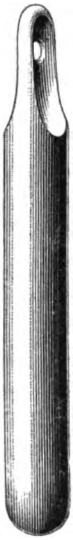


FIG. 10

14. Lead Weights.—The weight of lead is about 80 per cent. greater than that of cast iron; hence, **lead sash weights** must be resorted to where the construction of the pockets is too narrow to permit the use of iron weights, or where heavy plate glass is used. They are also used in cases where the sash are very wide and low, as here a short weight must be used in order to obtain the necessary travel for the sash.

Lead weights can be procured in either round or square shapes, and of any diameter or measurement to suit existing conditions, but they are generally made to special order. A wrought- or malleable-iron eye, or fastening, for applying the cord or chain is usually inserted at the top. The cost of lead

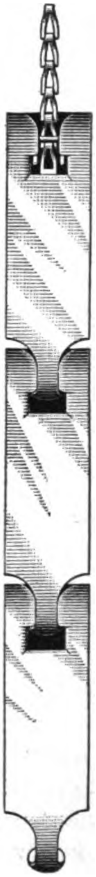


FIG. 11

weights, however, is generally five times as great as that of iron weights.

15. Sectional Sash Weights.—There is a form of sash weight in the market known as the **Walda sectional weight,** which is illustrated in Fig. 11. This weight, as will be observed, is so arranged that units or sections may be detached or added, as desired, to diminish or to increase the weight. Such a weight can be nicely adjusted to counterbalance any sash, and has the advantage over the cast-iron weight in that each part is interchangeable and no mistake can be made in ordering, as the necessary weight for any sash can be made up on the site.

TABLE V

WEIGHT, DIAMETER, AND LENGTH OF SASH WEIGHTS

Weight Pounds	Diameter Inches	Length Inches	Weight Pounds	Diameter Inches	Length Inches
3	1⅜	8½	12	1¾	20
3½	1⅜	9¾	13	1¾	21½
4	1⅜	11	14	2	18
4½	1⅜	12¼	15	2	19
5	1½	12	16	2	20¼
5½	1½	12½	17	2	21½
6	1½	14	18	2	22½
6½	1½	15	19	2	23½
7	1½	16	20	2	24½
7½	1½	17	21	2⅛	25
8	1½	18	22	2¼	23
8½	1⅝	16½	23	2¼	24
9	1⅝	17½	24	2¼	25
9½	1⅝	18½	25	2¼	25½
10	1⅝	19½	26	2¼	26
10½	1⅝	20½	27	2¼	27
11	1⅝	21½	28	2¼	28
11½	1¾	19	29	2¼	28½

FINISHING HARDWARE

METALS AND THEIR MANIPULATION

16. Historical.—From the days of Tubal-Cain, "an instructor of every artificer in brass and iron," to the present time, no element in the world's composition has rendered greater service in advancing man's development than has the uninviting metal known as *iron*.

Recent discoveries show the very ancient existence of iron in Assyria, and also in Egypt under the Pharaohs. It was found in considerable quantities in Syria, in Canaanite times, and many tools and implements of warfare were made from it. The Chalybes, located near the Black Sea, were in Biblical times considered famous workers in "northern iron," while Damascus steel, for ages, has been justly celebrated.

Copper was well known to the Israelites and Egyptians before the Exodus, and for many years previous to that event the Egyptians obtained it from Arabia. It was also a native product of Palestine, and was very largely exported from Cyprus, whence its name.

Tin was early known in the Orient, being one of the imports of Egypt from Spain, through the Phenician merchants, who also obtained it from Britain. It was one of the principal commodities in the marts of Tyre, and was used as an alloy with other metals.

Gold and *silver*, the precious metals, are mentioned in the earliest times and were highly esteemed; they were utilized in the manufacture of articles for domestic use, for personal adornment, and for ceremonial accessories. These metals were obtained by the Hebrews from Arabia, Ethiopia, Egypt, and Spain. Gold was used as a medium of exchange, like money, as early as the time of Abraham, but was then weighed, not counted. Silver was profusely used at that time in the East, and seems to have been very abundant in the time of Solomon. An alloy of gold and silver, called *electrum*, was also used.

Zinc was discovered in 1520 by Paracelsus, an alchemist and astrologer of Europe, and was immediately adopted as a valuable alloy.

Bronze, a composition of copper and tin, seems to have been much used in Europe before the adoption of iron for the same purposes, as Roman remains testify; this was probably due to its greater ease in working.

Brass, a composition of copper and zinc, soon became popular, owing to its being more easily worked than bronze.

Burnished brass is mentioned in Ezekiel, but is considered to have been an alloy of copper, there being a white metal, greatly used for ornaments in the East, called *white copper*.

Locks and contrivances to secure protection and privacy were originally made of wood, and a wooden lock (the oldest yet discovered) was actually found in the ruins of Nineveh. This lock appears to have been used on a gate of an apartment in one of the palaces of Khorsabad. The ancient Egyptians constructed locks and keys from brass and iron, thus showing their creative mechanical skill, while the ornaments discovered in the royal tombs display the high order of their art.

The Greeks and Romans were skilled workers in the metals, and many beautiful examples remain to attest their ability and ingenuity.

During the dark ages, following the conflict waged between the barbarians of Northern Europe and the Romans, and resulting in the fall of the Roman Empire in the 5th century, the art of working the metals nearly disappeared. Not until the Revival of Learning in the 13th century did the art again receive the attention to which it was entitled. As late as the reign of Edward III, of England, in the 14th century, the iron pots and pans of the royal kitchen were listed among the "jewels of His Majesty." During the 15th and 16th centuries, great progress was made among all civilized nations by skilled artificers. Much of their work is still extant, and their "cunning of hand" and "keenness of intellect," as displayed in their products, serve, like torches, to light the way to higher endeavor. From that time to the present, great progress has been made. During the latter half of the 17th, the 18th, and the beginning of the 19th centuries, especially, art work received a great impetus, and much of the present-day adaptations are modeled from the schools of ornament then produced.

17. **Metals Used in Hardware Manufacture.**—The metals chiefly used in manufacturing the products of the smiths' art are iron and steel and the copper alloys known as brass and bronze. Iron remains as the chief material of construction for all the cheaper grades of hardware, while brass and bronze are more generally used for "destructible," or wearing, parts and the finer and more elaborate decorative work. These alloys also adapt themselves admirably to the great variety of finishes that are now in vogue. Iron is also used considerably for elaborate decorations in wrought and cast designs, and is very desirable in the "rustless-iron" finish, technically known as "Bower-Barff," which derives its name from its two inventors.

White metal has been recently introduced, but will probably not be so universally adopted as brass or bronze, owing to the great number and variety of items used in hardware fittings, which would necessitate stores carrying a full line of white-metal goods. At present, white metal is used principally for hospital buildings and bathrooms.

18. **Commercial and Stock Designs.**—In recent years, manufacturers have made rapid strides in producing beautiful and elaborate trim in the several schools of ornament, and the most exacting critic can now procure artistic designs. The finishes are made to harmonize or contrast with any color treatment.

The principal hardware manufacturers can provide from stock, locks, hinges, and escutcheons finished in any manner and designed in any of the following schools of architectural ornament. They will also provide hardware in special designs from sketches furnished by the architect, including armorial or emblematic designs, if required. These several schools of ornament are here arranged in alphabetical order.

Byzantine
Colonial
Elizabethan
Empire
English Renaissance
Flemish
Francis I
French Renaissance
German Renaissance
Gothic, English
Gothic, French
Gothic, German
Gothic, Italian
Greek
Henry II
Indian
Italian Renaissance
Japanese
L'Art Nouveau

19. Finishes.—The basic metals upon which are applied the variety of finishes now obtainable, are iron, steel, brass, bronze, and white metal, of which the three latter, even in their highly polished natural state, are the most durable. These metals will not rust or corrode when exposed as will iron or steel, and when tarnished can be readily cleaned and polished.

Nearly all the fancy finishes are obtained by electroplating and acid treatment on the natural metals, the finish being then lacquered to preserve it. Some of these finishes are very attractive and desirable, but where exposed to constant usage, have not the durability of the natural metals, as they cannot be polished or cleaned without the finish being injured or destroyed.

Many architects or owners purposely select applied finishes with the object in view that they will need little attention. When selections are being made for exterior purposes or where there is likely to be excessive handling, it is best to select the darker shades with sanded surfaces. For interior purposes, the more delicate finishes are desirable for the decorative effect; they also wear reasonably well.

The variety of colors and shades of finishes is exceedingly large, and the choice of color, like that of texture, depends on the character of the design and on the personal taste of the one making the selection.

The standard finishes that can be had are numerous. Many of them may be obtained in various shades of oxidation and in from one to four different textures of surface. The most popular finishes are as follows:

Pompeian bronze
Sage-green bronze
Royal copper bronze
Ormolu metal
Boston finish
Enameled
Japanned
White metal
Brass
Bronze
Copper
Nickel
Silver
Gold
Bower-Barff
White enamel
Gun-metal brown
Verde antique
Statuary bronze
Olive bronze

HINGES, HINGE BUTTS, AND SPECIAL HINGES

20. Strap Hinges.—The common wrought hinges used to apply on the surface, for hanging doors, etc., and generally used in connection with rough work, such as bins, sheds, barns, etc., where a strong, serviceable hinge that may be easily applied is required, are known as **strap hinges.** They are constructed of wrought metal of various weights, according to the size of the hinge, and are stamped or cut from sheet metal, with *knuckles*, or sockets for the pins, formed on the strap; the pins passing through the knuckles are well riveted. There are two kinds of strap hinges; namely, *light-strap* and *heavy-strap hinges.*

The **light-strap hinge,** which is shown in Fig. 12 (*a*), is so termed because of its light construction and narrow joint. This hinge is made in inch sizes, varying from 3 to 16 inches in length. By inch size is meant the longest dimension when the hinge is closed; thus, a 6-inch strap hinge is 12 inches long from end to end when opened. They are listed and sold by the pair.

The **heavy-strap hinge**, which is shown at (*b*), is similar to the light hinge, but is made from heavier metal and has large dimensions at the joints, or knuckles. This type of hinge is used where a strong, substantial hinge is required. The heavy-strap hinge is made in inch sizes, from 4 to 16 inches in length. The 4- and 5-inch sizes are listed and sold by the pair, the 6-inch and larger sizes being listed and sold by the pound; the larger the hinge the lower the price per pound.

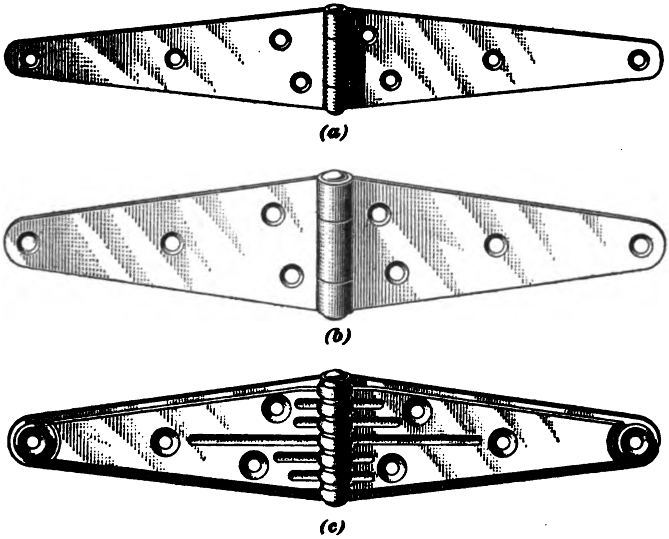


Fig. 12

As shown at (*c*), the heavy-strap hinges are also made with corrugated knuckles, which give additional strength where the construction is weakest. These are termed **corrugated-strap hinges.**

All of the hinges described are also made in plain steel, japanned or galvanized, and may have brass pins or rivets.

21. T Hinges.—As will be seen from Fig. 13, **T hinges** are so called to distinguish them from the strap hinge, as well as because of their construction, which is in the form of the letter **T**. The **T** hinge is used for practically the same purpose as the strap hinge, but is superior to it in strength, from the fact that its knuckle is wider than that of the strap hinge. **T** hinges are made in light, heavy, and extra-heavy grades, the former and latter types being shown in Fig. 13 (*a*) and (*b*). In arranging the sizes of **T** hinges, the measurements are given for the length of the strap only; the leaf of the hinge forming the **T** with the strap is not considered. Thus, a 6-inch **T** hinge measures 6 inches from the pin to the end of the strap leaf. **T** hinges may also be obtained in stamped metal, with corrugations, as shown at (*c*). These hinges can be had in all finishes. The light and heavy grades, as well as the 4- and 5-inch extra-heavy grades, are sold by the pair, while the larger sizes of extra heavy are sold by weight.

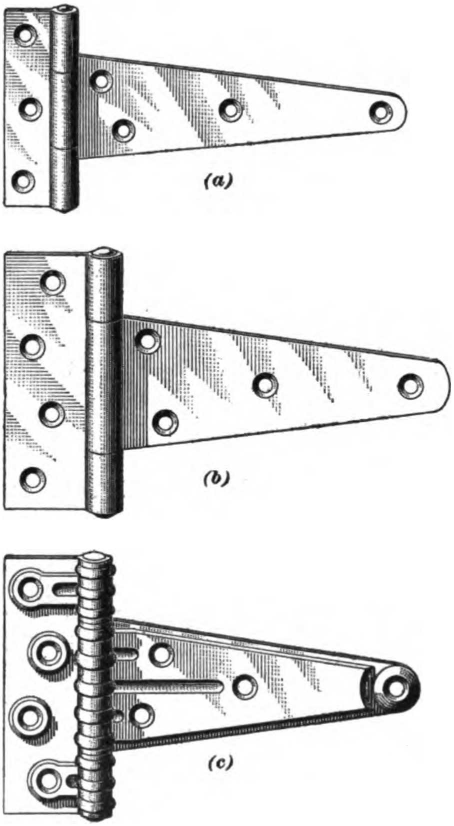


Fig. 13

22. **Hinge Butts.**—In the selection of hardware for building purposes, no other article deserves more consideration, and probably receives less, than the **hinge butt.** This type of hinge is used for the purpose of hanging all of the exterior and interior doors of buildings, and is usually secured to the edge of the door and to the hanging stile of

the frame with screws, the greater part of the appliance being thus unobtrusive and partly hidden from view. The hinge butt supports the entire weight of the door, and, ordinarily, is constantly in use, so that it is subjected to excessive strain and considerable wear. It is evident, therefore, that great care should be exercised in selecting hinge butts, so that proper sizes and qualities suitable for the purpose intended may be obtained.

23. Cast-Iron Hinge Butts.—Hinge butts made of cast iron are used extensively in the cheaper class of buildings built for speculative purposes, in which cost is usually the controlling factor. An ornamental type of **the cast-iron hinge butt** is shown in Fig. 14. Butts of this type are not extensively used at present, but may be obtained in various finishes to imitate bronze or brass, and may likewise be obtained without ornamentation. As the genuine Bower-Barff finishes are produced with equal facility on iron or steel, a large number of the better grade of cast butts are finished in this manner.

While the cast-iron hinge butt is not so durable as the steel butt, being more easily broken when subjected to excessive stresses, it wears somewhat better at the joints, or knuckles, than the ordinary steel butt. Therefore, the extra-heavy types of cast iron are becoming more popular for entrance doors, etc., where a good wearing

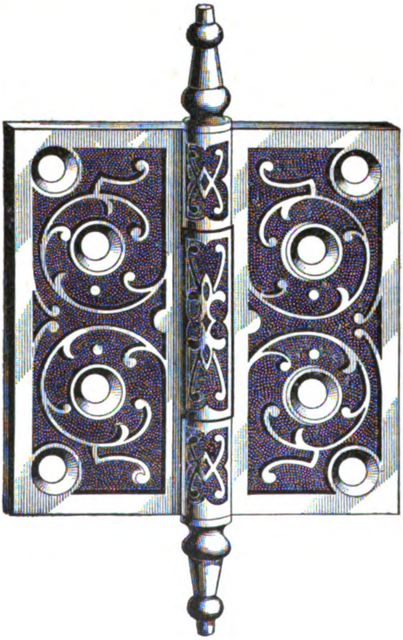


FIG. 14

butt is required, and where economy is the essential feature. The heavier grades of cast-iron butts can be procured with steel bushings inserted into the joints.

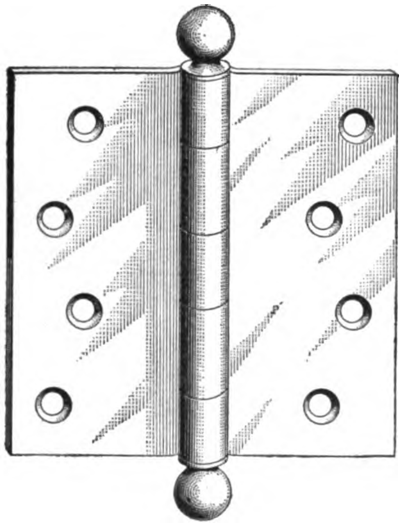


FIG. 15

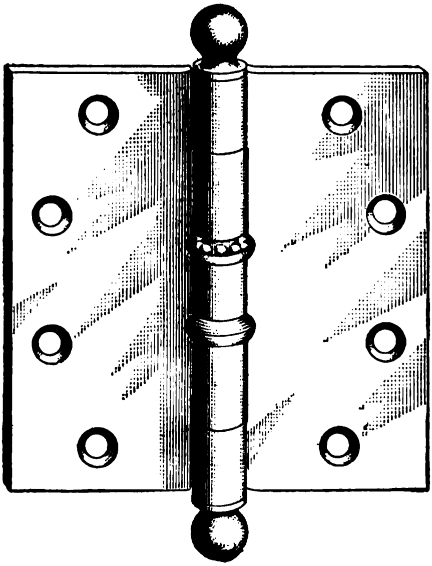


FIG. 16

24. Steel Hinge Butts.—In recent years, the **steel hinge butt,** which is shown in Fig. 15, has been substituted for the cheaper cast-iron butts. The better grades are made with ball tips, as indicated in the figure, and these are now almost universally used for medium-class work and for the better class of interior work. Owing to the fact that they are made up with smooth surfaces, the steel hinge butts are adapted to the various buildings and finishings without grinding or buffing. These butts are stamped and formed by machinery, so that their cost is reduced to a minimum; they can be sold for less than cast-iron butts, and also possess the advantage over the latter in that they are practically unbreakable. The ordinary grades are not suitable for large and heavy entrance doors that are constantly in use, for they are made of soft steel and wear readily at the joints. Thus, in time, they will allow the door to sag and thereby necessitate readjustment, or the planing of the door at the sill. For such class of work, steel hinge butts should be used that are provided with ball bearings, as shown in Fig. 16, or with hardened-steel washers inserted at the joints, as shown in Fig. 17.

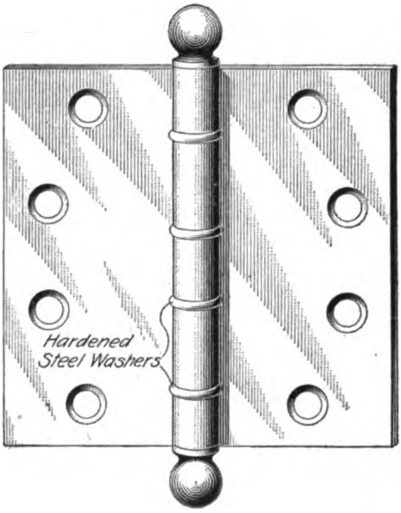


FIG. 17

These steel butts are also made in smaller sizes, and for bookcases, cupboard doors, and light work of this kind in ordinary building operations, they are used almost exclusively, having practically forced the small cast butts for this class of work out of the market.

25. Cast-Bronze and Brass Butts.—All types of **brass** and **bronze butts** are made in several grades and qualities, and it is difficult to determine the grade after they have been placed in position. It is therefore advisable for the architect or building superintendent to make a careful inspection of this hardware, to determine whether it is furnished according to specification. Brass and bronze butts are made in light, or commercial, heavy, and extra-heavy grades, and in all cases should be steel-bushed, self-lubricating, and provided with five knuckles. The high-grade butts are now manufactured with ball bearings at the wearing joints. The construction of a solid bronze, ball-bearing hinge butt is shown in Fig. 18. In this figure, the hardened-steel balls are shown at *a*, and the cones, which are also of hardened steel, at *b*. Bronze hinges constructed in this manner can be obtained at a slight additional cost above the ordinary steel-bushed hinge.

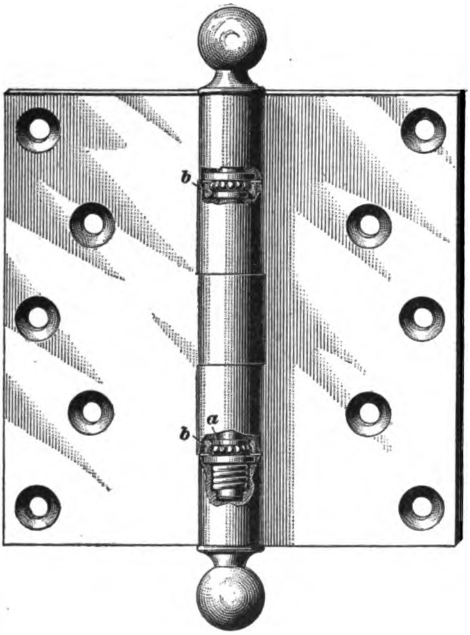
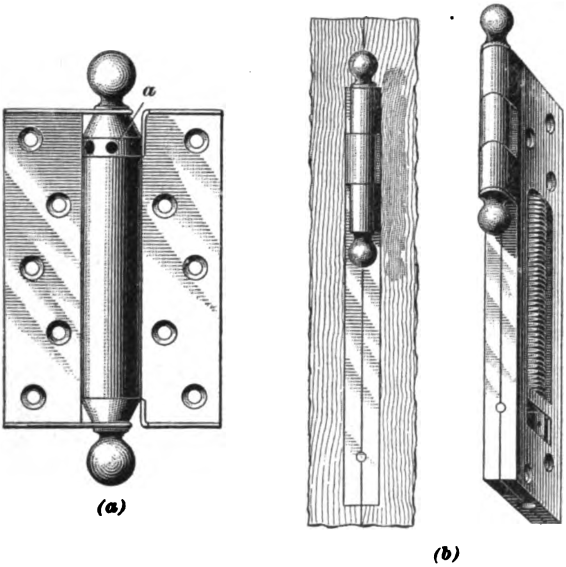


FIG. 18

Where hinge butts are exposed to the weather, as when used for exterior doors, bronze or brass butts should always be employed; and for extra-heavy doors that are in constant use, only the extra-heavy types should be used if permanency and durability are desired. There are a number of cheap grades of bronze, steel-bushed hinges on the market that are made of wrought or sheet metal. This kind of hinge has no merit, and should not be used on work of any quality.

26. Sizes of Hinge Butts.—The standard hinge butts are always square, but they may be procured in irregular sizes, at additional cost. In indicating the size of irregular hinge butts—that is, the butts that are not square, and that are consequently not standard—two dimensions must always be given. The first dimension stated should indicate the height of the butt, and the second the width of the butt when it is open. Thus, a 6″ × 5″ butt is 6 inches high and 5 inches wide when opened. This rule for indicating the size of hinge butts is easy to remember, from the fact that it is the reverse of that ordinarily employed by builders when indicating the sizes of doors and windows, for here it is customary to give the horizontal dimension first and the height of the opening last.

27. Single-Acting Hinges, or Butts.—There is a large butt, or hinge, in the market that has a coil spring either between the knuckles, or enclosed between the leaves. This device is known as the **single-acting hinge,** and is illustrated in Fig. 19. At (*a*) is shown the *Bommer single-acting hinge*, which has a spiral spring enclosed within the casing formed by one of the knuckles. The tension on this spring can be increased by operating the collar at *a* with a pin, or bar. At (*b*) is shown a single-acting spring hinge known as the *Chicago single-acting spring butt.* This hinge butt has a spiral spring that is encased between two leaves. In operating, this spring always tends to throw the door back to its closed position. These two kinds of single-acting hinges are used more than any other hinge of the

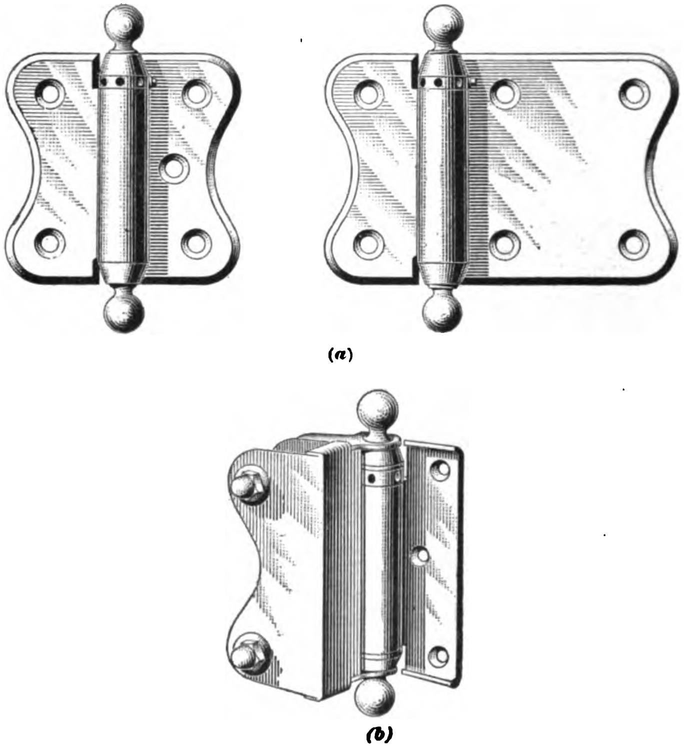


(a)

(b)

FIG. 19

same nature now in the market, but for doors of large size the liquid door check is preferred, although it is more costly. Single-acting hinge butts are used principally for hanging water-closet slat doors; and they are also used for light doors that do not reach the full height of the opening, and which have no jambs. The Bommer hinge, as shown in Fig. 19 (*a*),



(*a*)

(*b*)

FIG. 20

has an advantage on account of the simple means provided for adjusting the tension of the coil, or spring, by which the momentum of the door in swinging to and fro can be reduced to a minimum, thus shutting the door with little noise as it strikes the stop.

Two other types of the Bommer single-acting spring hinge are shown in Fig. 20. At (*a*) are shown two types of single-acting, surface, spring hinges that are used for lavatory doors, while at (*b*) is shown a similar single-acting spring hinge arranged for securing to a marble or slate stile or partition. These hinges are commonly supplied in highly polished nickel plate, brass, or bronze. The clamp hinge illustrated at (*b*) is made to secure to slabs of marble or slate from 1 to 2 inches in thickness, advancing by quarter inches. This type of hinge is also adjustable $\frac{1}{8}$ inch over and under the stated sizes.

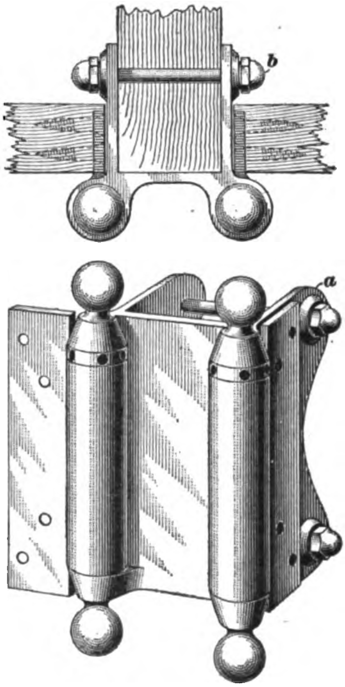


Fig. 21

The Bommer yoke-spring hinge is also made as illustrated in Fig. 21. This yoke hinge consists of two single-acting hinges hung right and left of the same partition on one box flange, the yoke or box flange being constructed as shown at *a*. As the box flange of this spring is not adjustable, the exact thickness of the marble, or partition, and the door must always be stated in ordering these hinges.

The single-acting spring hinges with clamps, as just described, are fastened to the marble partitions separating water-closet compartments by means of bolts having capnuts, as shown at *b*, Fig. 21, and are thus secured firmly in position. Special single-acting hinges may be obtained with a reverse spring that can be regulated to hold the door partly open, instead of in a closed position.

28. Double-Acting Hinges.—The **double-acting hinge** is similar in construction to a single-acting hinge, except that it is arranged so that the door can swing both ways. These hinges are combined in one piece of hardware, as illustrated in Fig. 22. Such hinges are much heavier and more costly than the single-acting hinge, and they are generally used for entrance doors of hotels and public buildings, and for doors between kitchen and pantry or dining room in private residences, where a door that will swing both ways and return to a closed position is desirable. The double-acting hinge is usually subjected to excessive wear and strain. Care should therefore be exercised in selecting this type of hinge; also, in determining the size, it is better to have a hinge slightly larger than required rather than one that is too small. While double-acting spring hinges made of cast iron may be obtained, those of the latest manufacture are of steel. They may also be procured in brass or bronze, and of any desired finish to match the fixtures and other hardware.

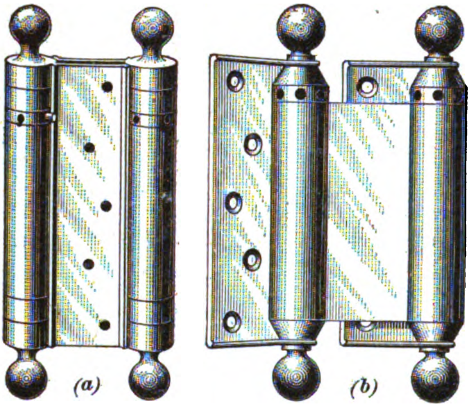


FIG. 22

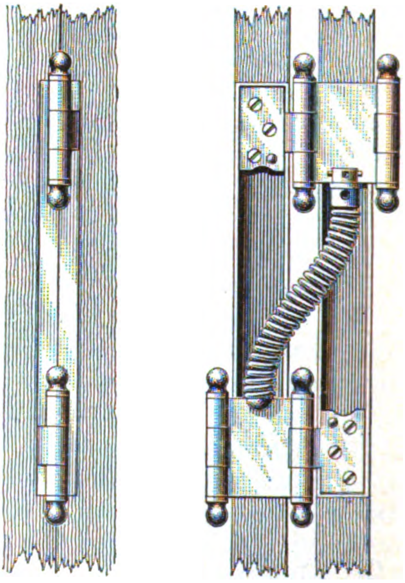
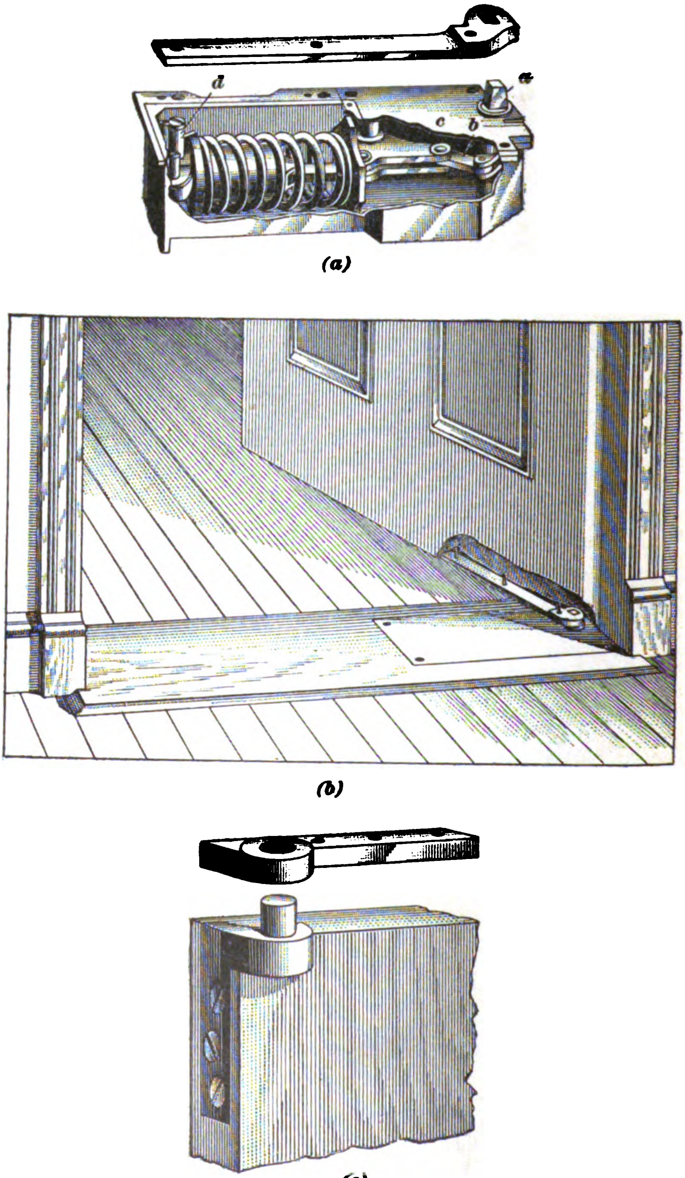


FIG. 23

In Fig. 23 is shown another type of double-acting spring hinge that is not so compact as those illustrated in Fig. 22. This hinge, as shown, is operated by a coil spring that fits into a rabbet formed in the two leaves of the spring; thus, the coil is invisible when the door is closed, or in its normal position. This hinge obtains a good purchase on the door and jamb.

29. Floor Hinges.—A device is made for hanging single- and double-acting doors by means of pivots, or trunnions, placed at the top or the bottom. The top pivot is usually inactive; that is, it has no spring or other device, and is simply a trunnion, or pivot, with the necessary plate to engage it fastened to the edge of the door trim. The bottom piece of hardware, on the other hand, is arranged with a pivot and a coil spring, and has various mechanisms for operating the door positively and silently.

In Fig. 24 is illustrated a **single-acting, checking-spring hinge.** This spring hinge is known as the *Bardsley*, and its mechanism, which is enclosed in a cast-iron box, is shown at (*a*). This box, or case, is set into the floor, the top plate being made flush with the top of the floor, as shown at (*b*). The operating bar, or pivot, of the hinge has a square end, as shown at *a*, that engages with the plate secured to the bottom edge of the door, and is connected to the mechanism by means of a crank and connecting link, as at *b*. After being set into the floor, the cast-iron box, or case, containing the spring, piston cylinder, etc. is filled with oil or other non-freezing liquid, and sealed by means of the top plate *c*. The action of the door in opening compresses the spring and operates the piston in the cylinder. The spring operating to close the door also moves the piston and forces the oil in the cylinder out through a by-pass, the flow being regulated by the adjusting screws *d*, which are on a level with the top plate. In this manner, the door is closed surely but gently, from which the hinge derives its name of checking-spring hinge. Hinges of this type can be used without any modification of the door or frame, but are not extensively used on account of their high price and the cost of application.



(a)

(b)

(c)

FIG. 24

For pivoting the door at the top, there is provided a top pivot and plate, as illustrated at (*c*). This pivot is applied to the edge of the door stile. Both the top pivot and bottom hinge plates on the door are offset.

Double-acting floor hinges are rapidly displacing double-acting spring hinges. This is due to the fact that when the former hinges are employed the door is pivoted at the top and bottom and the weight of the door is not carried by the coils of the spring, as in the double-acting spring hinge. The floor type of double-acting hinge carries the weight of the door on a ball bearing in the box, or case, let into the floor, as shown at *a*, Fig. 25, the coil performing only the function of closing the door. The hinge illustrated is not only a double-acting hinge, but is also a checking hinge, and for this reason is known as a **double-acting, checking-spring hinge.** In operating, this spring hinge not only closes the door, but prevents it, when closing, from oscillating after the door has reached its neutral, or closed, position.

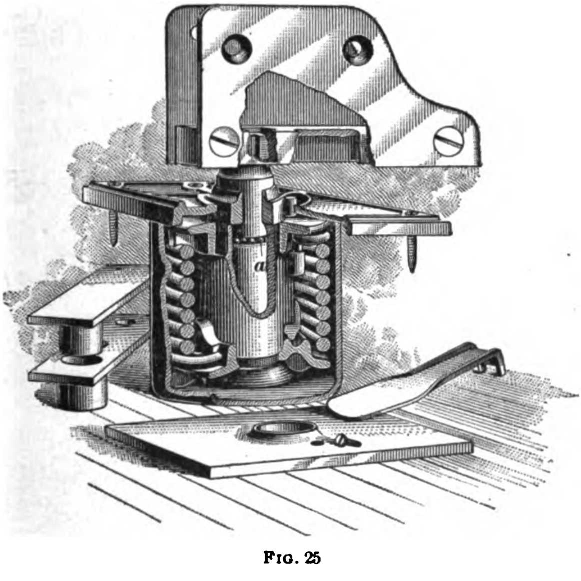


FIG. 25

There are numerous double-acting floor hinges in the market that are not of the checking type. Some of these are the *Atlas* and *Simplex*, made by Bardsley, the *Bommer*, made by Bommer Brothers, together with the *Chicago*, *New Idea*, *Matchless*, *Chief*, and *Columbia*, made by various manufacturers. All of these hinges embody practically the same principle, but differ somewhat in mechanism.

30. Outside Blind and Shutter Hinges.—The outside shutter, or blind, is still much used in the construction of dwelling houses, and a great variety of hardware is made to use in conjunction with hanging these devices. Only the most common of the many available types of this kind of hardware, however, will be treated here.

The hinge illustrated in Fig. 26 may be classed among the oldest types of shutter hinge. This hinge is made of cast iron and is formed with a gravity-locking device intended to hold the shutter in position when opened against the building. It is known as the *Lull and Porter hinge*, and is made in various sizes that are designed to throw the shutter from 1½ to 6½ inches away from the casing, so as to clear all obstructions consequent to the various constructions. A sill catch must be used in conjunction with this hinge, in order to hold the shutter in place when closed and to prevent it from blowing open.

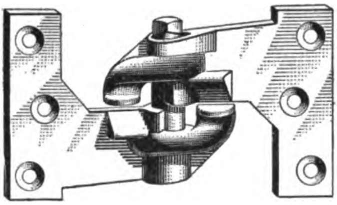


FIG. 26

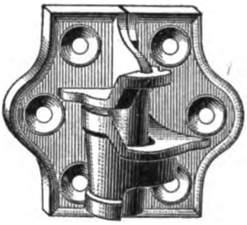


FIG. 27

A similar type of hinge, known as the *Clark hinge*, is illustrated in Fig. 27. This hinge is made of cast iron, and in three sizes, which are arranged to throw the blind 1¼, 3¼, or 4¼ inches from the casing. The hinge with the largest throw is used on brick buildings. With this hinge, as with the one just described, a sill catch must be used to keep the shutter closed.

In specifying cast-iron hinges of the types just considered, it is well to mention that they shall be extra heavy, from the fact that there are so many in the market of such light construction as to be practically worthless.

A type of the **gravity-locking hinge,** which is better than the cast-iron hinge, is illustrated in Fig. 28. This hinge is made entirely of steel, and is known as the *Stanley gravity blind hinge.* There is only one size of this hinge manufactured, and it is used for frame buildings. All of the parts of this hinge are interchangeable and reversible, so that it may be used for either right- or left-hand blinds.

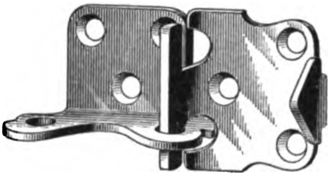
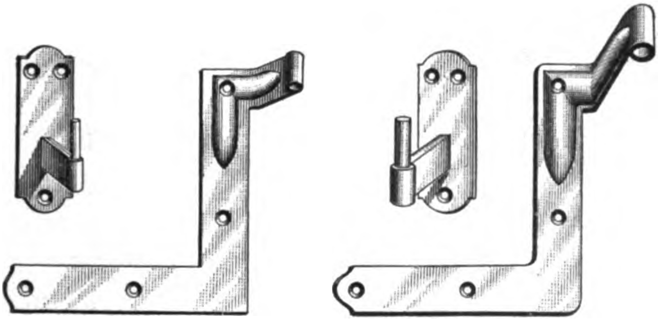


FIG. 28

There is a wrought-steel hinge, known as the *Stanley blind hinge,* which has not the gravity-locking device, but which obtains a greater purchase on the shutter. This hinge is illustrated in Fig. 29; the hinge shown at (*a*) is for frame buildings, while that shown at (*b*) is arranged for brick walls.


(a) (b)
FIG. 29

Another type of hinge made entirely of wrought steel, and known as the *New York blind hinge,* is shown in Fig. 30. This type of hinge has a long strap that extends on the top and the bottom rail of the shutter and thus tends to prevent the blind from drooping. This strap also strengthens the shutter by relieving the mortise and tenon of the rail and stile from the strain. The New York blind hinges are made in two styles. The hinge shown at (*a*) is intended for frame buildings, while that at (*b*) is made with an offset to throw the shutter clear of a brick jamb. These hinges are ordinarily used with blind adjusters, or fasteners, and for very high blinds, a center, or auxiliary, hinge is used.

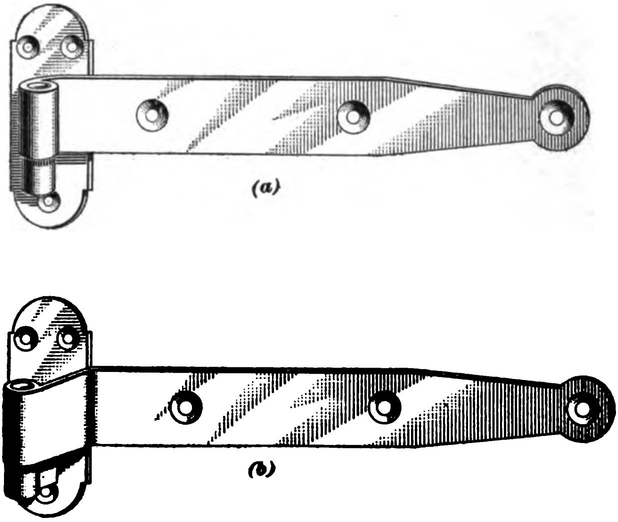


FIG. 30

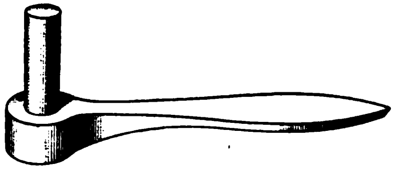


FIG. 31

There is another type of strap hinge similar to those just described, the butt of which consists of a pin and staple, as shown in Fig. 31. This staple is secured by driving it into wooden blocking in the brick joints. Hinges of this type are used extensively in localities where brick buildings are numerous.

31. Inside Blind, or Shutter, Hinges.—The use of inside blinds, or shutters, is general with the better class of domestic buildings, and for hanging these shutters, three kinds of hinges are used, depending on the number of folds in the shutter and the manner in which they fold back on each other. Usually, the *butt* and the *back flap*, as shown in Fig. 32 (*a*) and (*b*), are used. Where the shutter has three folds, however, a *knuckle butt*, as shown at (*c*), is employed. The purpose of the knuckle butt is to cause the folds to take such relative positions as will enable them, when open, to close properly into a pocket, or recess, formed in the window frame.

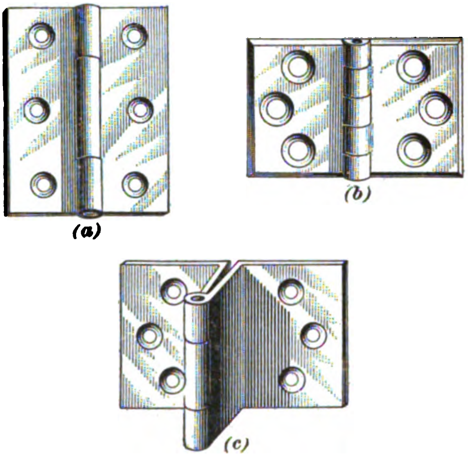


FIG. 32

32. Invisible Butts, or Hinges.—A secret, or **invisible, hinge,** known as the *Soss hinge*, has recently been placed on the market. This hinge, which is illustrated in Fig. 33 (*a*), consists of a semicircular plate, which is attached

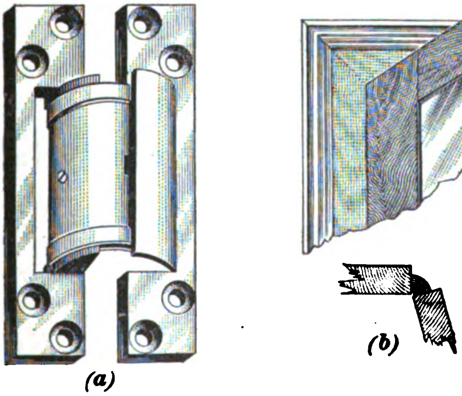


FIG. 33

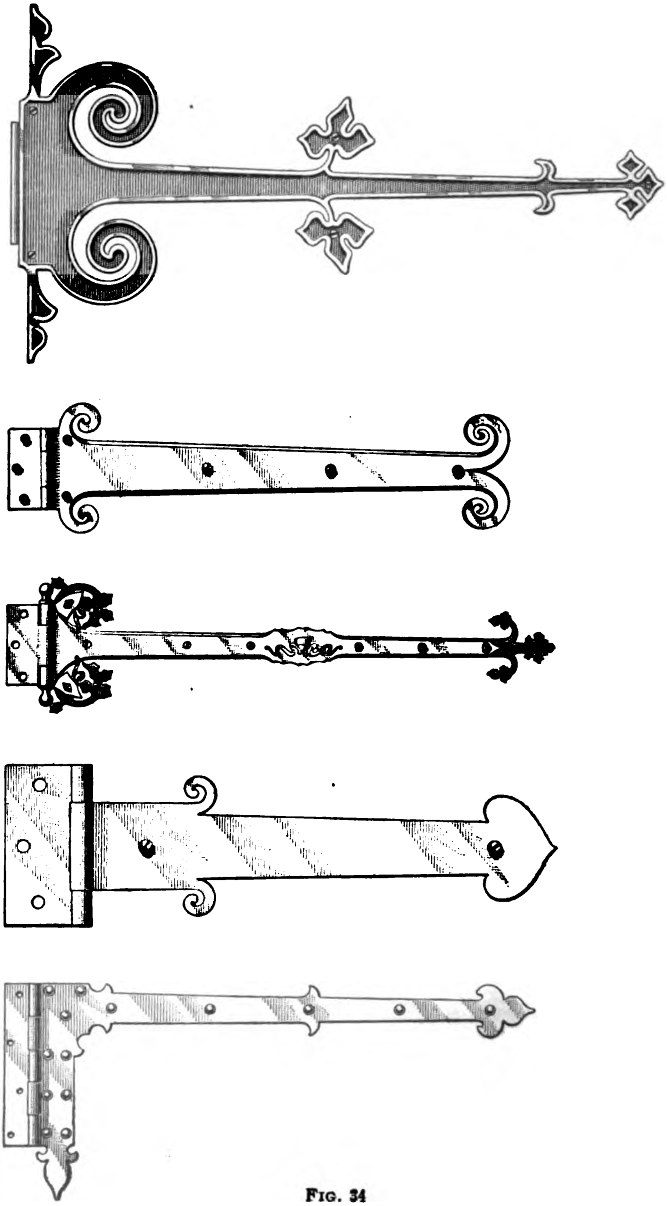


FIG. 34

rigidly to the door section, and a movable semicircular plate on the jamb leaf, which telescopes the section on the door in closing. These hinges are invisible when the door is closed. The disadvantage in the use of these hinges is due to the fact that they have only one wearing joint; they are also somewhat complicated and expensive. As shown in Fig. 33 (*b*), they have no throw, or offset, and consequently

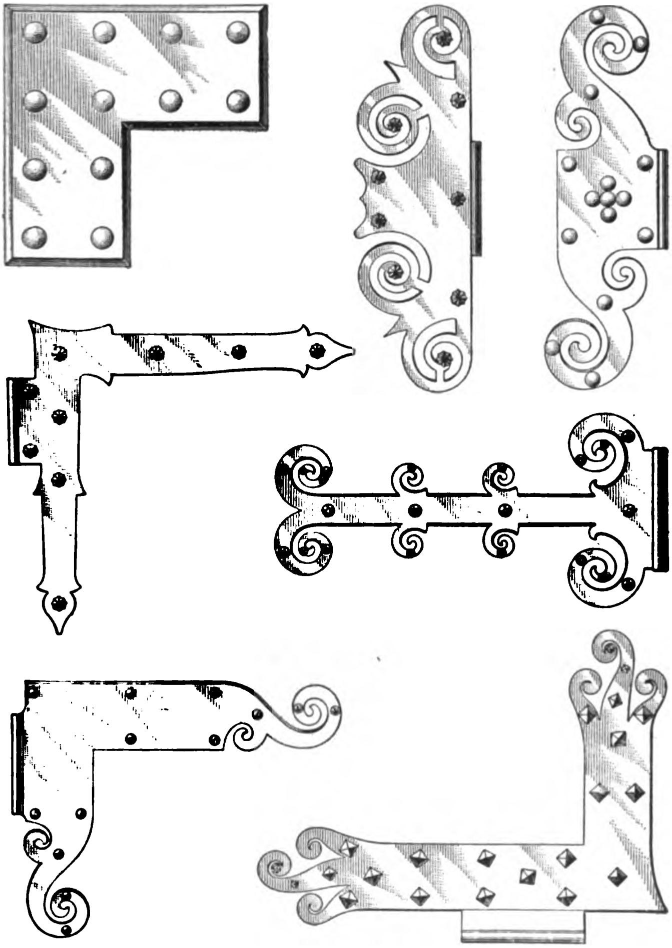


FIG. 35

the door does not clear the baseboard, or trim, in opening. The larger size of hinge has a throw of 1 inch, which is not ordinarily sufficient for doors. These hinges, however, have their use for such mill work as seats, secret jambs, drop, or folding, leaves, etc., and for this class of work are the best in the market.

33. Strap and Corner Hinge Plates.—Medieval hardware was the product of the blacksmith and the whitesmith, the former working with forge and hammer, and the latter with chisel and file, the material being wrought iron. The butt hinge was unknown, while the strap, or surface, hinge was in universal use; and, as this was wholly in sight, it naturally became the subject of decoration, chiefly in outline, but occasionally in surface ornament also. With the adoption of the butt hinge for general use, the opportunity of utilizing the hinge to decorate the surface of the door disappeared, but with the modern revival of decorative art the use of constructive metal work as a feature of surface decoration for important doors was restored. This was accomplished by combining with the modern butt a surface plate that represents the strap hinge. Obviously, the width of the butt of a hinge plate should correspond with the height of the butt hinge with which it is to be used, and both should be of the same metal and finish. The other dimensions are governed by the size of the door and by taste, as is true also in the case of corner plates. A varied and artistic selection of typical strap hinges and corner plates is given in the groups of designs shown in Figs. 34 and 35.

LOCKS AND THEIR APPURTENANCES

34. Locks in General.—In no other line of hardware is there such a variety of grades and types as there is in door locks. In general, locks may be designated as *surface* and *mortise locks*, the former being secured to the surface of the door and entirely exposed to view, while the latter are let into a mortise cut in the edge of the stile. Besides these two general kinds of locks, there are several special locks, which will be fully explained. As to quality, locks may be classified in three grades; namely, *common*, *medium*, and *high grade*.

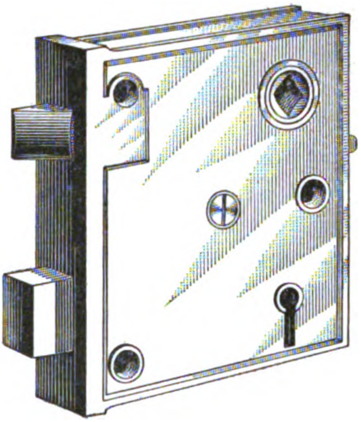
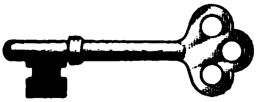


FIG. 36

35. Common-Grade Rim and Mortise Locks. The **rim lock**, as illustrated in Fig. 36, is generally used for buildings of the cheapest class, such as tenements and small houses. As cheapness is the controlling factor in such goods, especially the goods made for speculative building purposes, the quality diminishes with the price. For cheap work, rim locks are used on account of their low cost and because they are easily applied. They also require no trim, such as escutcheon plates, etc., and are complete when the spindle and the knob are furnished with them. Rim locks are made in various sizes and either square or rectangular in shape, the long dimension being placed either horizontal or upright. They may also be obtained with either iron or brass bolts, and are furnished with iron, tinned, or nickel-plated keys. The cheapest grades of rim locks are made with two bolts and one tumbler, while the



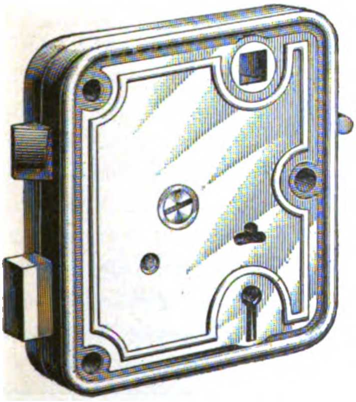


FIG. 37

better grades have an additional stop and a slide bolt with three tumblers.

Rim locks are generally constructed of cast iron, and in selecting them, a careful inspection should be made of the internal mechanism, choosing only those rim locks in which the bolts and the tumblers are constructed of steel or brass. Rim locks, however, are also made of all steel, and these are coming into general use. They present a somewhat better appearance than cast-iron locks, as may be seen from Fig. 37.

The cast-iron rim lock may also be obtained with an ornamental case. These cast-iron cases, as a rule, are finished in imitation of bronze. Such rim locks, however, are not in general use on account of their somewhat higher cost, and from the fact that their appearance is not greatly improved by the ornamentation.

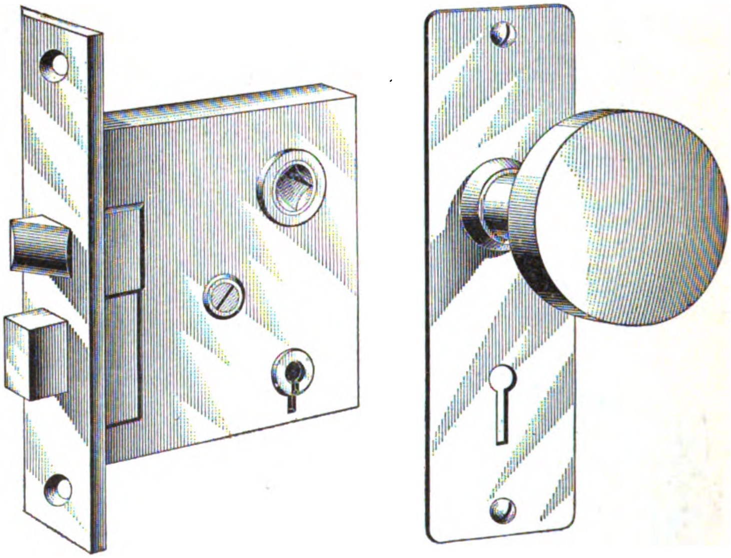


Fig. 38

Cheap mortise locks, or sets, are also largely used for the more common grades of work. They are sold in sets, that is, with escutcheon plates, etc. of steel or cast iron, both in plain and ornamental designs, as illustrated in Fig. 38.

The cheapest lock sets are fitted with pottery knobs, and the better grade, with metal knobs. All of these locks described are of poor construction, as quality is a secondary consideration.

36. Medium-Grade Mortise Locks.—The locks grouped under the term "medium-grade" hardware have been greatly improved in recent years and are adapted to a large range of uses, but they are especially made for residence work. In dwellings of the better class, the best types of rim locks are used for doors in attics, and basements, and for closet doors, but for all other doors, the **medium-grade mortise locks** are used. These locks are provided with cast- or wrought-bronze lock fronts, are made with from one to three lever tumblers, and have drop-forge steel cases. The locks are constructed with easy springs, which allow the latch bolt to retreat within the case on one light spring when the door is closed, and when the knob is turned, to operate the latch, both springs act jointly in order to overcome the friction of the knob and to throw the bolt back to central position. The mechanism of an easy-spring, mortise knob lock is illustrated in Fig. 39.

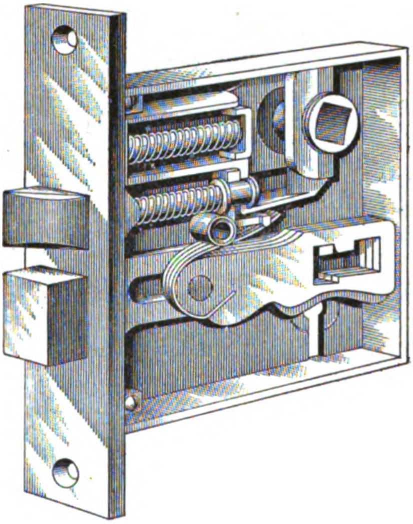
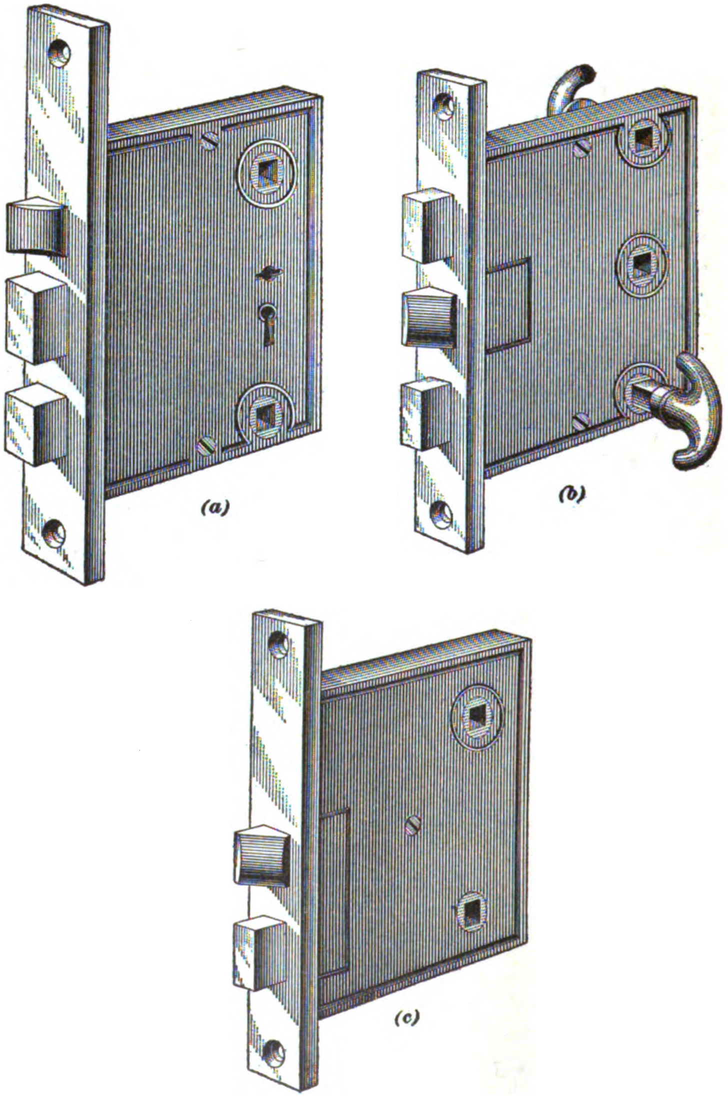


FIG. 39

In the group of locks embodying those of medium quality are included the three-bolt locks used for chamber and exterior doors, locks for communicating doors between chambers, and twin, or two-bolt, locks for twin bathroom or toilet-room doors, these being respectively illustrated in



(a) (b) (c)

FIG. 40

Fig. 40 (*a*), (*b*), and (*c*). All of these locks should be used with wrought- or cast-bronze trim, either plain or in design, and in finishes to suit. Locks for exterior doors, where security is important, should be selected with this object in view, and three-tumbler, or three-bolt, locks should be used.

37. High-Grade Locks.—There are a number of high-grade door locks and latches in the market for the equipment of first-class buildings, and frequently these locks are especially constructed to meet particular requirements. Among such locks are included, besides high-grade, three-tumbler locks, those that embody the cylinder principle and those that are equipped as master-key locks.

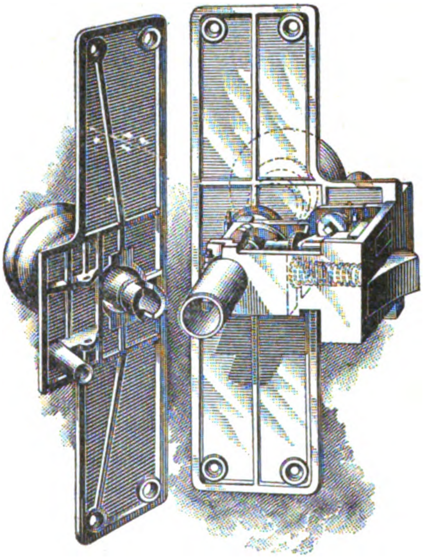


Fig. 41

The **unit-cylinder lock,** illustrated in Fig. 41, is made by P. & F. Corbin. This hardware specialty is a new departure in lock making. The mechanism of the lock is contracted into the smallest possible space, occupying only about 1½ in. × 3¼ in. Instead of being mortised into the stile of the door, as is usual with the mortise lock, a piece is cut entirely from the stile, as illustrated in Fig. 42. In order to prevent this operation from weakening the stile of the door, the unit-cylinder lock is provided with heavy escutcheon plates that are strongly ribbed on the back, so that when these plates are secured to the stile at the top and bottom, they supply the rigidity necessary to make up for the notching. As the name implies, these locks are made in a unit, and the keyhole to the cylinder lock is located in the knob. The unit-cylinder lock is made in two styles—with dead-locking latch bolt and with additional dead bolt.

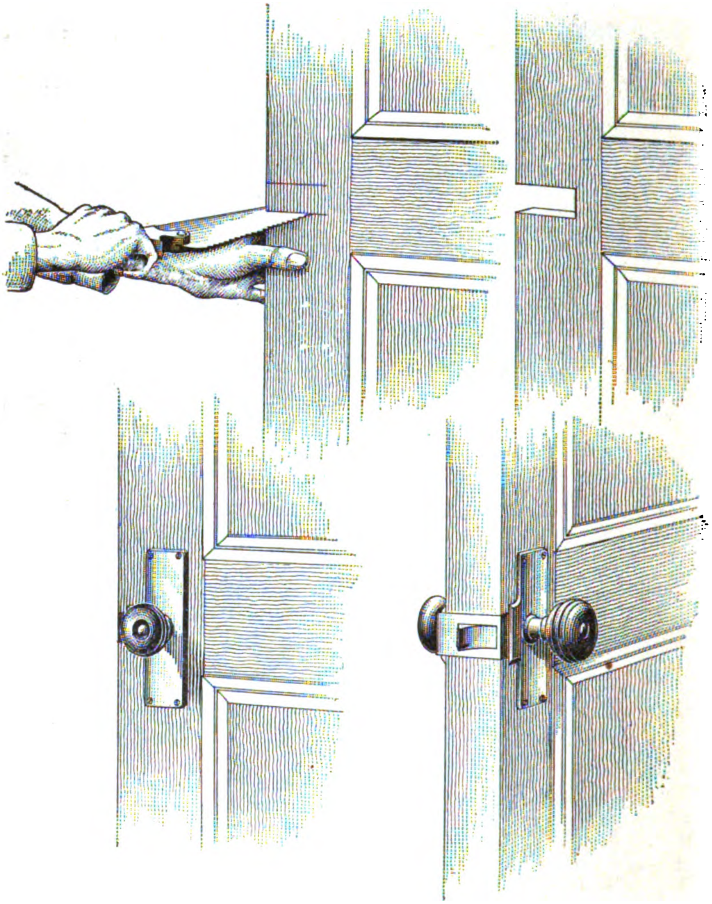


FIG. 42

38. High-Grade Interior Door Locks.—In Fig. 43 is shown a type of high-grade, **mortise-locking latch** for interior doors. These locks are of the heaviest construction, and are fitted with either brass or bronze fronts. The bolts are operated with two or more tumblers constructed on an improved pattern, and are of fine workmanship. The trim for a lock of this character should be of the very best grade, with knobs of the screwless-spindle type, which will be explained later.

The escutcheons should be of the high-collar or the bracket-bearing type, and should conform to the character of the locks in quality and finish. On the most important work, it is always expedient and usually feasible to obtain expert advice from manufacturers or from dealers representing the manufacturer, whose intimate knowledge of the product will be of great assistance to the architect or owner in making suitable selections. The use of high-grade hardware requires a considerable expenditure, and the necessity for expert advice consequently becomes more imperative if the best results are to be obtained.

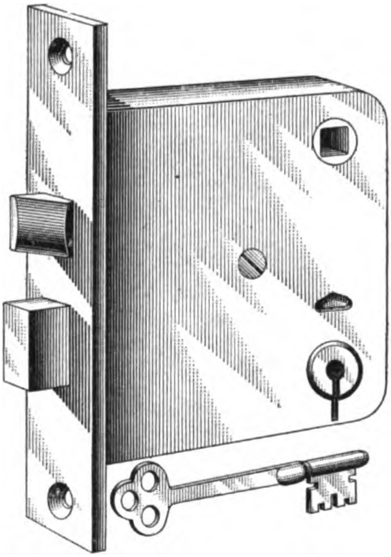


FIG. 43

39. Master-Key Locks.—The type of lock known as the **master-key lock** is generally used for public or office buildings, hotels, and occasionally in the better class of residence work. These locks can be grouped into two classes; namely, the *Yale*, or *cylinder*, and the *lever-tumbler types*, the class first mentioned being the most desirable.

In the lever-tumbler type, illustrated in Fig. 39, the tumblers, or wards, are so arranged that each lock can be operated only by its particular key, the keys for all rooms being different and non-changeable; all of the locks, however, can be operated by a key made for the purpose, termed a **master key.** Each lock of this type has two sets of tumblers; one set is operated by its individual key, and the other, being uniform in all locks of the series, is acted on by the master key. Such locks may be obtained either in the cheaper kind, with one tumbler and twelve changes, or in the most intricate styles of hotel locks, with five tumblers and 48,000 changes in one set, and all operated by one *master key.* The cylinder lock of this type is illustrated in Fig. 44, which shows a Yale & Towne, mortise, front-door lock.

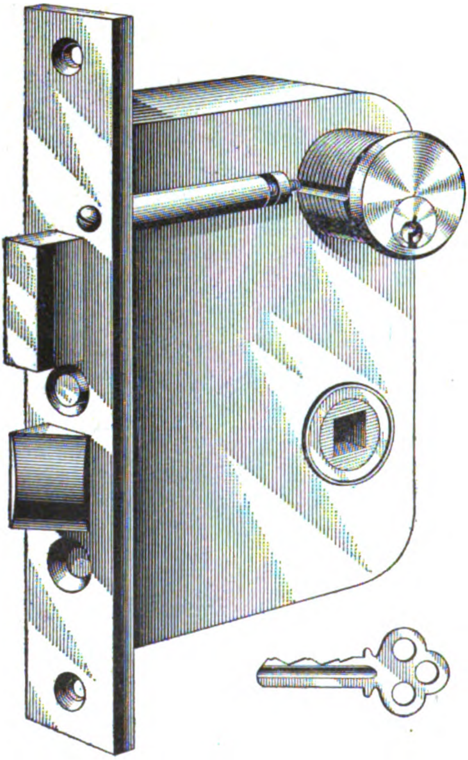


FIG. 44

40. Details of the Yale Type of Master-Key Locks. The **Yale** type of cylinder lock, which is illustrated in Fig. 45 (*a*) and (*b*), is much preferred, on account of the great security it gives and the small key required by it. This lock is made in three systems; namely, the *regular*, the *concentric*, and the *paracentric*, or *duplex*.

In the **regular system,** one regular cylinder is controlled by the change and master keys, the pin tumblers being cut in two places, so that the change key brings one set of the abutting planes of the tumbler in alinement with the surface of the cylindrical plug. This plug is arranged so that a separate key is required to operate each lock, the other

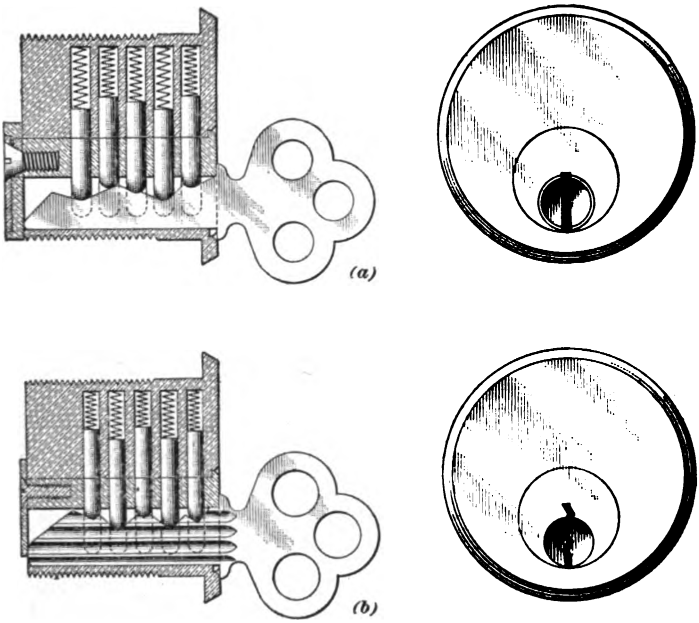


FIG. 45

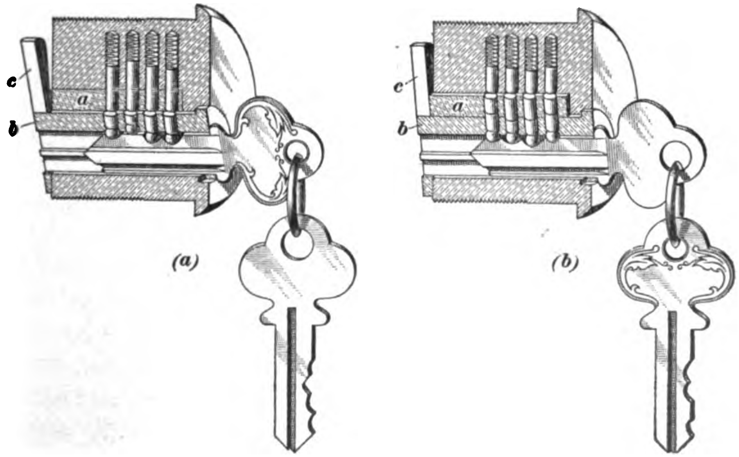


FIG. 46

line of cleavage through the blocks being the same with all locks throughout the series, so that they may be opened with the same key.

The **concentric cylindrical arrangement** of this type of lock is shown in Fig. 46 (*a*) and (*b*). Here, there is a larger cylinder encircling the key plug. This is known as the master-ring, or larger, plug, and is indicated at *a*. When the change key is inserted in the key plug *b*, the lower series of breaks in the pins comes into alinement with the outer edge of the plug, as shown at (*a*), and allows it to revolve in the master ring, the cam on the inner side at *c* actuating the lock. When the master key is inserted, the upper series of breaks comes into alinement with the outer edge of the master ring, as shown at (*b*), allowing the plug and the ring to rotate together with the turning of the key, and thus to produce the same result as that caused by the operation of the change key.

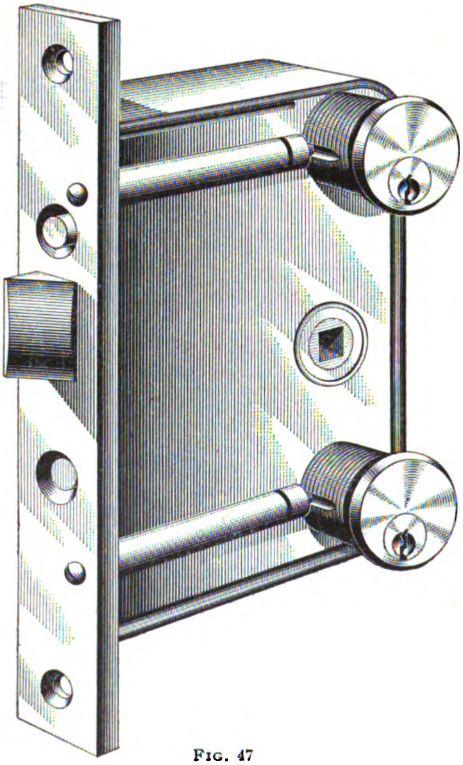


FIG. 47

The **paracentric system,** sometimes called the *duplex system*, consists in having two separate cylinders to each lock, as illustrated in Fig. 47. One of these cylinders, generally the upper one, is operated by the change key, and the lower one, by the master key. The interior construction of the lock is so devised that each key performs the necessary function of operating the same bolt, so that the individual lock may always be opened by the change key, and all locks of the series by the master key. This latter system of lock construction is more expensive than the one-cylinder type, but it possesses an advantage in that it provides greater security when a limited number of locks are grouped in one series.

41. Owners or officials of large office buildings and industrial works now avail themselves of the master-key system just explained. They are able to obtain mortise locks, rim locks, and padlocks, all arranged to operate with a master key, in one series. In fine residence work, this system is also adopted. Such a system of locking is easily recognized as convenient, especially where subordinates are held responsible for certain rooms or departments to which they, individually, have access, as all of the rooms or departments may be entered by the manager or superintendent by the aid of the master key.

A series of master-key locks may also be "submaster-keyed" by dividing it into subordinate groups. In such a case, each group is operated by a master key of its own, and all the subordinate groups are controlled by a grand master key. For example, a six-story office building could be furnished throughout with locks having non-changeable keys; the doors of each floor could be operated separately by a master key; and the doors of the entire building could be operated by a grand master key. The convenience of such a system is readily apparent in large buildings where each janitor is responsible for a certain floor, and where the head janitor, manager, or owner, has control of all the locks through the grand master key.

In some instances, for additional security and for special work, the corrugations in the keyway are changed in shape so that the manufacturers' regular type of key will not enter the keyway, or plug, thus allowing no chance for the regular type of key to operate the lock.

42. Locks for Residence Use.—The **front-door lock** is distinctly a lock having two bolts; namely, a *dead bolt* and a *latch bolt*. The latter is operated by the knob, and is so arranged that, by means of stop-work in the lock front, the outer knob may, at will, be set so as not to operate the latch, the latch bolt being operated only from the outside by a key.

The cylinder type of front-door lock illustrated in Fig. 44 is the best lock for this purpose, as it provides the greatest security. This lock is operated by a convenient key of the Yale type, which throws both latch and dead bolt with one insertion into the cylinder.

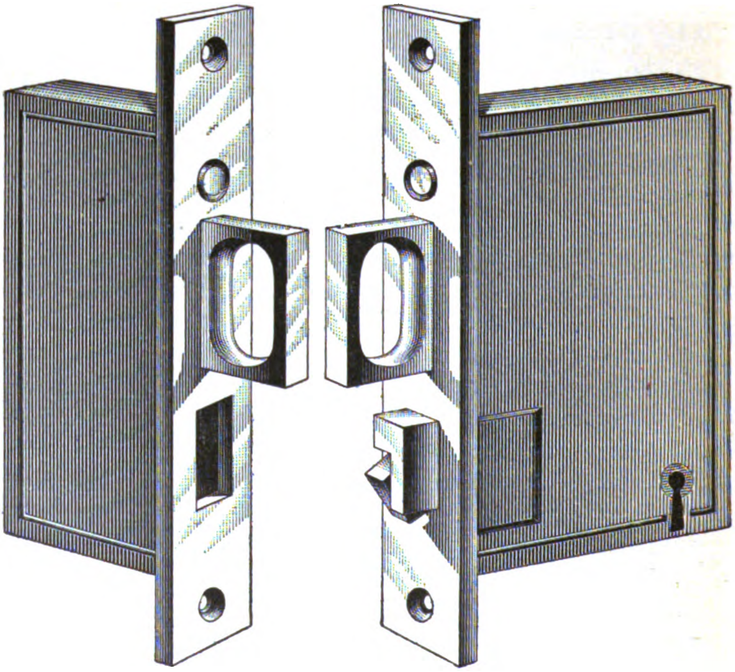


FIG. 48

Three-tumbler, front-door locks and latches are to be had at a low cost, and are used in the cheaper class of dwellings. When the residence has an inner, or vestibule, door, a similar lock is used without the dead bolt; this lock is termed a *vestibule latch*. In all cases the vestibule lock should "key-lock" with the front-door lock, so that one key will operate both. The other exterior doors of a residence should have either Yale locks master-keyed to the front door, for the better class of work, or locks of the 5-inch, three-bolt variety, that are furnished with an extra bolt in addition to the dead bolt, the third bolt being operated by a thumb knob on the inside. When a cheaper trim is wanted, a 4-inch, two-bolt lock, supplemented by a separate mortise or rim bolt, may be used.

For the first- or parlor-floor folding doors, 4- or 4½-inch, two-bolt, mortise locks are ordinarily employed. Where the doors are sliding, a 5½-inch, sliding-door lock with dead bolt and pull, or handle, is provided. The pull, or handle, is operated, or thrown out, when needed by pushing a button, or stop, in the lock. This special type of sliding-door lock is illustrated in Fig. 48.

For bedroom doors, a lock similar to that used on the minor exterior doors is usually employed. The lock for these doors may be either a 5-inch, three-bolt lock, or a 4-inch, two-bolt lock supplemented with a mortise bolt. For communicating doors, it is best to use a three-bolt, knob lock, the latch bolt of which is operated by the knob from either side. Arranged above or below this latch bolt are two dead bolts, each being operated by its respective thumb piece on opposite sides of the door. Locks of this character are made for both swinging and sliding doors.

43. Locks for Twin-Closet and Other Interior Doors.—Twin, or double, doors are sometimes used between rooms in residences to deaden sound or to increase privacy. Such doors should be fitted with the same type of lock as other communicating doors, except that the lock should be provided with two bolts, the same as the lock used for bathroom doors. These locks are arranged with special trim on the abutting face of each door, this trim having only a slight projection, and knobs or lever handles projecting as little as possible, in order to avoid interference on account of the limited space between the doors. Bathroom doors are best fitted with a thumb bolt, either combined with a lock or separate.

In fitting closet doors, it is best to use a two-bolt lock about 4 inches in size, with trim on both sides, so that the door may be operated from inside in case it is accidentally closed on a person in the closet. The possibility of this happening is slight, and usually a saving is effected by using a knob latch without a dead bolt and a pair of knobs with roses.

For basement or attic doors, a cheap type of mortise lock is appropriate, or a rim lock may be used, if cost is a consideration. Where care is exercised in the selection of locks in any one building, great convenience will result from having all the different classes of locks about the building of the same grade, so that they may be master-keyed in one set and thus give the owner control, with one key, of all the locks. Each lock, however, will have its own individual, or change, key, and should be selected and ordered with this object in view. Another convenience may be had by ordering each room and closet door keyed alike throughout the house, or alike throughout each floor, so that the loss of a key will cause little or no inconvenience.

44. **Hotel and Office Locks.**—The purpose and use of master-keyed locks has already been explained, but the employment of such locks in large groups, as in the equipment of hotels and office buildings, requires further discussion. The term *corridor door* designates the entrance from a corridor or a hallway to a bedroom or an office, while *communicating doors* are those between adjoining rooms. Frequently, these doors are double, and are then known as *twin doors*, while the term *closet doors* is self-explanatory. Each of these doors requires a *knob lock;* that is, a lock having the latch bolt operated by the knob and the dead bolt operated by a key. Sometimes, in the case of locks on closet doors, the dead bolt on communicating-door locks is omitted, and a thumb bolt substituted. While all of the locks thus far

enumerated are used in hotels, and most of them in office buildings, technically speaking, a *hotel lock* is a master-keyed knob lock for doors from the corridor to bedrooms, while an *office lock* is an inverted lock; that is, a lock with the keyhole above the knob. These latter locks are usually master-keyed, especially for the doors from the corridor to the office. Such locks as these may be master-keyed on any of the systems, as previously explained. For office work, a small key is desirable, so that cylinder locks are ordinarily employed, as the key for the operation of such locks may be conveniently carried. For hotels, however, a high-grade lever-tumbler lock with round, substantial keys is desirable, because the keys are liable to hard usage, and should not be convenient to carry in the pocket.

Hotel keys vary widely in arrangement, as well as in size, quality, and price. The kind of action, or mechanism, to be adopted in a hotel lock is frequently determined by the preference and experience of the hotel manager, and it is desirable that he should be consulted in advance; but the location and use of each door should be considered in the selection of the locks for this character of building. It will thus be seen that the subject of hardware for a hotel is one that requires the most careful consideration of the architect.

The grouping of locks in a hotel should be studied, and, usually, the best plan in large hotels is to group all of the locks on each floor under one master key and to provide a different master key for each floor, care being taken to limit the issue of master keys to the smallest possible number of responsible persons. In some cases, a grand master key is also provided that will open all the locks on every floor. This arrangement of the locks entails an additional expense, and also has the disadvantage that, in case the grand master key is lost, all of the locks controlled by it should at once be set to a new combination, in order to prevent access by the person into whose hands the key has fallen. This procedure is both troublesome and expensive.

The foregoing remarks relating to hotel locks apply equally to office locks, especially as to the arrangement for the operation with the master key. In other respects, however, the locks for an office building differ considerably from those used in hotels, for a hotel lock must secure the door both when the room is occupied and when it is not, whereas an office lock is used chiefly to secure it when not occupied. In consequence of this, certain differences in action are employed. All office locks have a latch bolt that is operated by the knob from both sides and yet permits free ingress and egress. Various methods, however, are employed to lock the door against ingress except by means of a key. Sometimes this is accomplished by means of a separate dead bolt operated by a master key from either side; in other cases it is accomplished by a latch bolt only, by providing the latter with a stop-work like a front-door lock. By this arrangement, the outer knob may be stopped so that the latch bolt cannot be operated from the exterior except by the key; and,

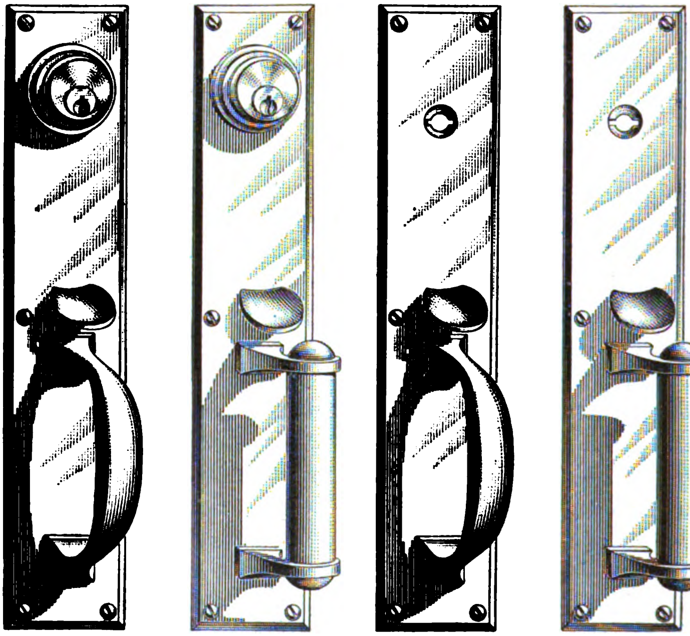


FIG. 49

again, the latch bolt may be dead-locked from the outside by the key. The choice of these arrangements is a matter of personal preference.

45. Store-Door Trim.—The technical term **store-door lock** originally designated a heavy rim or mortise dead lock, but is now applied to a combined lock and latch, the former being operated by a key from either side, and the latter by a thumb piece located above the pull handle. Such locks are made in a large variety of sizes and styles, the best being of the cylinder type, as shown in Fig. 49. In this lock, the latch is operated by the thumb piece during the day, while the dead latch secures the door at night.

Plates and handles for the combined store-door lock and latch are also made in many sizes and styles, from the plain rectangular type to the most ornamental forms. Such trim offers good opportunity for effective decoration, and no embellishment is so effective for a store's entrance door as a pair of handsome plates and handles of appropriate design. For such trim, it is not uncommon to provide an outlay of from $25 to $30 per door. Some of the more elaborate store-door handles are illustrated in Figs. 50 and 51. The trim illustrated in these plates is very carefully selected by the architect to match the style of architecture in which the building is designed, and the finish is selected with as much care.

46. Padlocks.—While **padlocks** are not ordinarily included in builders' hardware, they are extensively used for factories, stables, and other buildings of this character; thus some care should be taken in their selection. Padlocks are made in a great variety of sizes, styles, and qualities, and retail at prices ranging from 10 cents, or less, to $5. Where these locks are exposed to moisture or to the weather, they should be of bronze or of brass, with all of the interior construction of the same material. If required for great security, that is, for places where they are likely to be subjected to violence, they should be very heavy, and preferably provided with steel shackles. Padlocks constructed on the cylinder-lock principle may be obtained, and

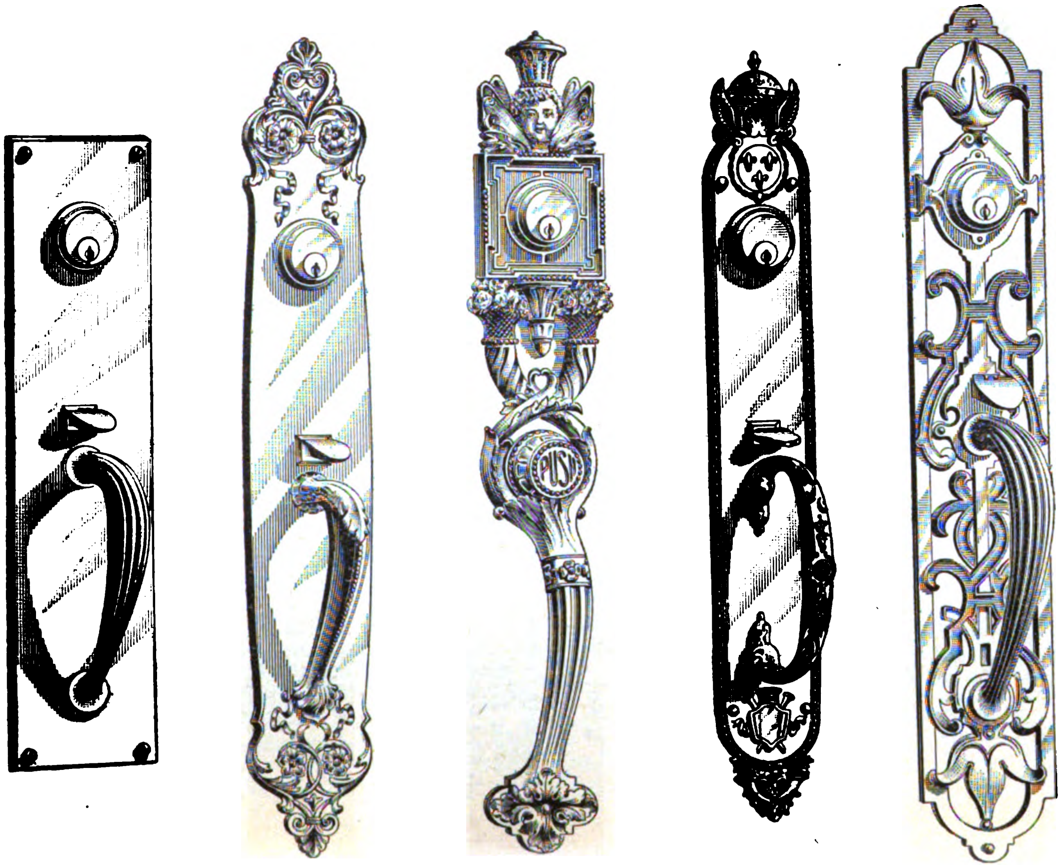


FIG. 50

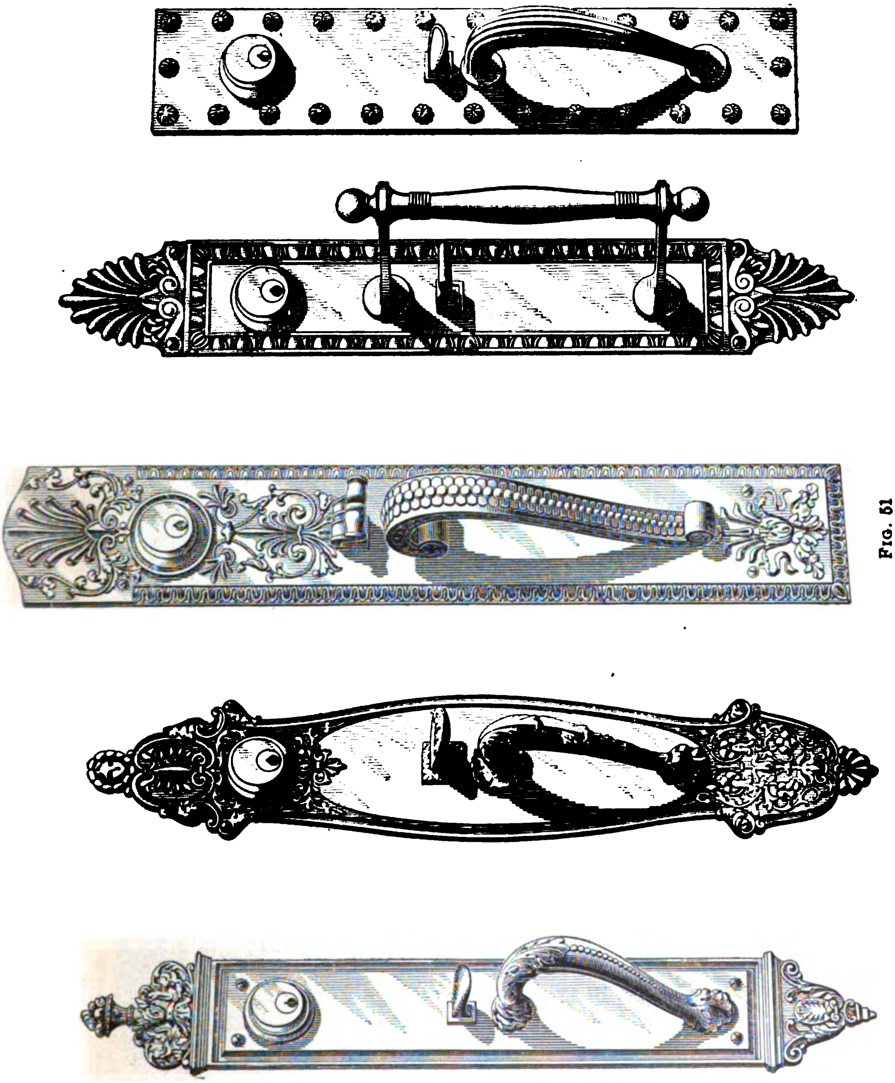


FIG. 51

should always be used where a series of locks that are operated by separate keys and controlled by a master key is employed. Ordinarily, a selection of padlocks should be made only after an inspection of the actual samples, and not according to catalog representations.

47. Cabinet Locks.—The locks used in cabinetwork are distinct from builders' locks, though they are occasionally used in the construction of the finer classes of interior finish, and, consequently, are of interest to the architect. **Cabinet locks** are made chiefly of wrought metal, and in a vast variety of kinds, sizes, and grades, so that care should be exercised in their selection. The leading kind of cabinet locks are drawer, or till, locks; wardrobe, or cupboard, locks; and chest, box, and desk locks. Special locks are also manufactured for many other purposes. For the best work, the Yale, or pin-tumbler, type is desirable where great security is required, but for ordinary uses, other types, with either flat or round keys, are available. Many of the cabinet locks admit of being master-keyed, and such locks are employed on lockers in club rooms, armories, etc.

48. Asylum and Prison Locks.—For the doors of cells in insane asylums, hospitals, and prisons, locks of special construction are required. For this reason, a distinct class of hardware is manufactured to meet the peculiar conditions

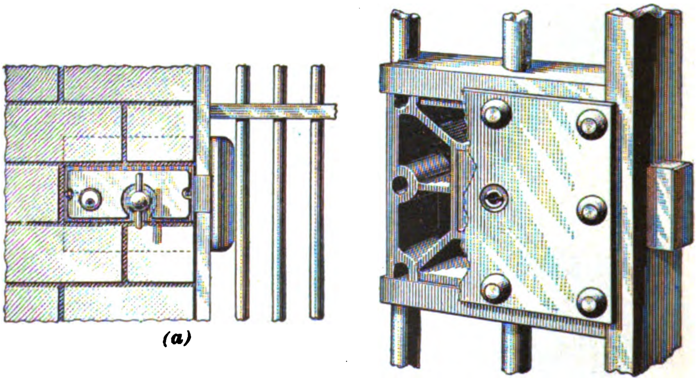


FIG. 52

that prevail. These locks, which are designed primarily to prevent escape from the rooms, or cells, are exceptionally exposed to attempts at tampering, and are especially constructed to meet these conditions. There is an extensive line of locks for these uses on the market. This line includes both the Yale type and the lever-tumbler type of lock, and these locks are constructed with both solid and barrel keys, thus affording a wide range of selection. All such locks must be made so as to be controlled by master keys.

In Fig. 52 are illustrated types of prison or asylum locks. The lock shown at (*a*) is embedded, or built, in the jamb, while that at (*b*) is secured to the door and the keeper is fastened in the jamb.

There are numerous other patterns of asylum and prison locks, such as those illustrated in Fig. 53. The lock shown at (*a*) is arranged to operate with a double-bitted key, while the one at (*b*) is operated by means of a Yale key.

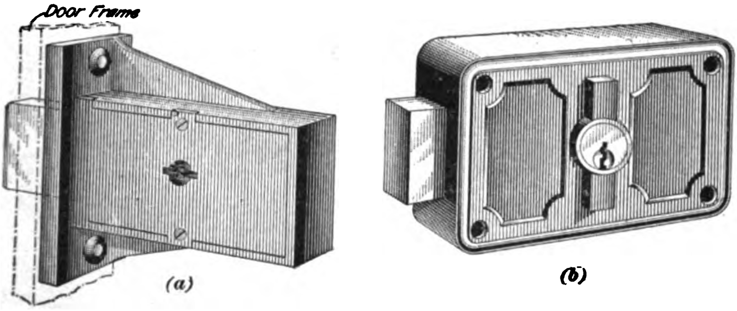


FIG. 53

Nearly all modern locks for this purpose are operated with either double-bitted or Yale keys, and those in common use are cylinder locks. Information regarding these types of locks should be obtained in advance, so that in preparing the plans and specifications, the type selected may be clearly indicated and the arrangements made for any special construction necessary to receive them. As the approved forms of asylum or prison locks are built in the masonry during construction, they must be delivered during the early stages of the erection of the building.

49. Bank and Safe Locks.—Locks for the doors of burglar-proof and fireproof safes and vaults constitute a group distinct from all others. These locks embody the most complicated mechanism, and represent the highest art of modern lock making. The architect in preparing plans of buildings for banks and trust companies is frequently called on to approve or to specify the fastenings for vault and safe doors. While the owners of such buildings will probably predetermine the kind of lock to be employed, nevertheless they will be guided by the advice of the architect in the selection of some particular make. The locks used on such vaults and safes comprise *time*, or *chronometer*, *locks; dial*, or *combination*, *locks;* and *safe-deposit* and *subtreasury locks.* There is also a device known as a *bolt-motor*, or *automatic lock*, which is an allied product. In the manufacture of these special locks, the skill of numerous experts and specialists is required, and as their knowledge is at the disposal of the architect or the engineer, they should be consulted in the selection of such important pieces of mechanism.

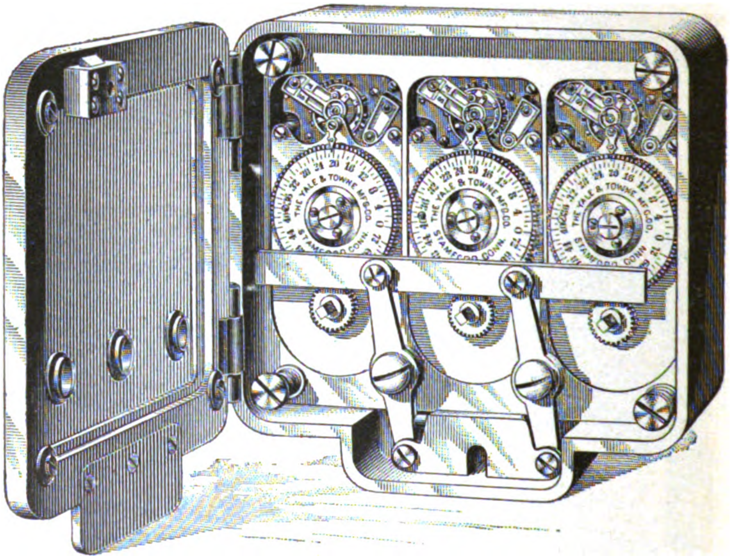

THE YALE & TOWNE MFG. CO.
STAMFORD CONN.

FIG. 54

The **time lock** is illustrated in Fig. 54, and is a locking device actuated by clockwork. This type of lock is used in connection with the heavy boltwork of a safe door, to prevent it from unlocking except during certain hours determined beforehand. This lock is now recognized as an essential part of the equipment of all first-class, burglar-proof vaults and safes. In its standard form, the time lock has three chronometer movements of the finest construction, each of which is competent to actuate the lock, so that, in this way, almost absolute reliability is insured.

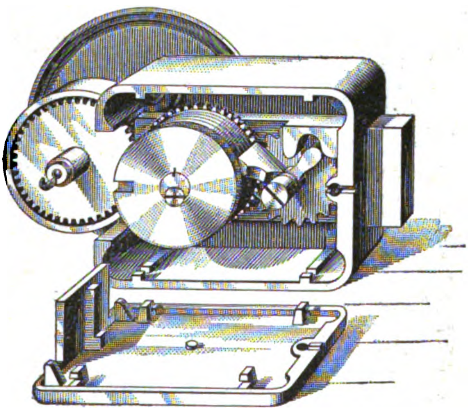


FIG. 55

A **dial, or combination, lock** is shown in Fig. 55. The combination commonly called the *dial lock* has completely superseded the key lock for use on safe and vault doors. Essentially, the dial lock consists of a bolting mechanism guarded by a set of changeable tumblers, or wheels. These tumblers are actuated by a spindle passing through the door, this spindle being provided on the outer end with a graduated dial. By rotating the dial in a certain manner, the dial can be set and the lock operated. Dial, or combination, locks are made in two grades, or varieties, designed respectively for burglar-proof and for fireproof safes. The lock intended for burglar-proof purposes is heavy and made to resist violence, while the other locks are smaller, simpler, and cheaper, intended only to secure the door against ordinary intrusion. Both of these locks should be absolutely "non-pickable."

In connection with the time lock, an automatic bolt-operating device is now used on burglar-proof safes. The

bolt motor is a mechanism containing heavy springs and is attached to the inside of a safe door. These springs are set, or braced, while the door is closed, and when released by the action of the time lock are capable of automatically retracting the heavy boltwork of the door. This construction obviates the necessity of any spindle through the door, and leaves the surface absolutely unbroken, without any communication between the interior and exterior.

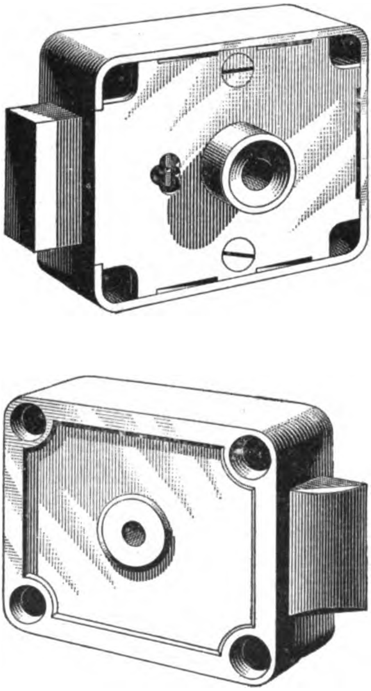


FIG. 56

A form of **safe-deposit lock** is illustrated in Fig. 56. This lock is of a new type, and is intended expressly for individual safes, or boxes, rented by the safe-deposit companies. Such locks are nearly always provided with a guard key, which is in charge of a custodian and common to all the locks in the series. Each lock has its own individual, or change, key, however, which differs from every other key in the series. Before a change key can be inserted into its lock, the guard mechanism must be unlocked by the guard key in charge of the custodian. This makes the presence of the latter a necessary preliminary to the unlocking of the box by the renter or his authorized agent. Many styles and sizes of safe-deposit locks are made to meet varying conditions, the lock probably most used being the Yale, or pin-tumbler, variety, in which additional security is obtained by using keys of special proprietary forms. For safe-deposit boxes of large size, the dial lock is often used.

Subtreasury locks are intended for use on the small safety chests, or "subtreasuries," often placed within a fireproof safe. These locks, which are illustrated in Fig. 57, are of various types and sizes, and are suitable for use on metal doors of all kinds.

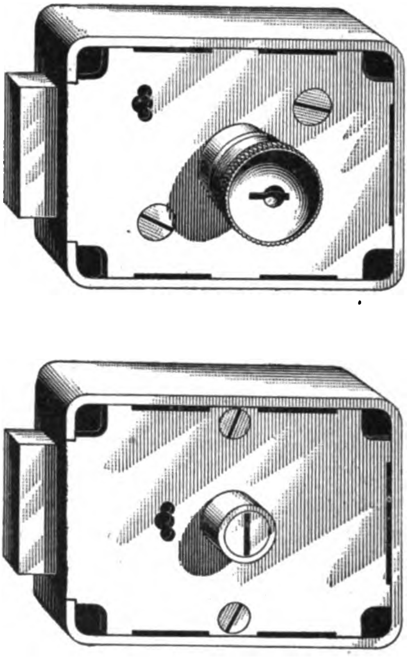


FIG. 57

50. Care and Maintenance of Locks.—Locks, like other pieces of mechanism, need reasonable care and attention to keep them in the best condition. As they contain moving parts, they are subjected to frictional wear and need occasional lubrication. Most of the friction, and consequently the wear, occurs in the beveled latch bolt, which may be readily lubricated. If the latch bolt is troublesome, its face and back should be cleaned with a cloth moistened with naphtha or kerosene, to remove any dirt. These surfaces should then be wiped with another cloth saturated with machine oil or, better, with vaseline. Any person can perform this simple work, and if it is done once or twice a year, it will keep the bolts in such condition that each door will close easily and quietly at all times. Another cause of trouble is the tendency of the old-fashioned knob screw to become loose, thus allowing the knob to pull from the spindle. Where such spindles are used, it is a good plan to inspect them occasionally and to tighten any loose screws. The best results from lock hardware, however, can be obtained by having all locks and hardware inspected by a lock expert about once a year.

51. Pottery Knobs.—Door knobs, which are important appurtenances to locks and latches, are made of many kinds of materials, and are fastened to the spindle in several ways. It is necessary, in order to make the proper selection of knobs for doors, to be thoroughly conversant with the various types on the market. The cheapest type of door knob is molded from several kinds of clay. These **pottery knobs** are secured to iron or bronze shanks by *leading;* that is, by setting them in molten lead, which, in hardening, secures the knob to the shank.

Pottery knobs are made in three styles, namely, *mineral*, *jet*, and *porcelain*. Mineral knobs are dark brown in color, while jet and porcelain knobs are, respectively, jet black and pure white. All of these knobs are highly glazed, and are used only with the cheapest grades of locks. Ordinarily, they are furnished with japanned mountings, or shank and rose; occasionally, however, they may be had with bronze-plated, real bronze, or brass mountings. The several styles of porcelain knobs are illustrated in Fig. 58. At (*a*) is shown the mineral knob, while at (*b*) and (*c*) are shown the porcelain and jet kinds.

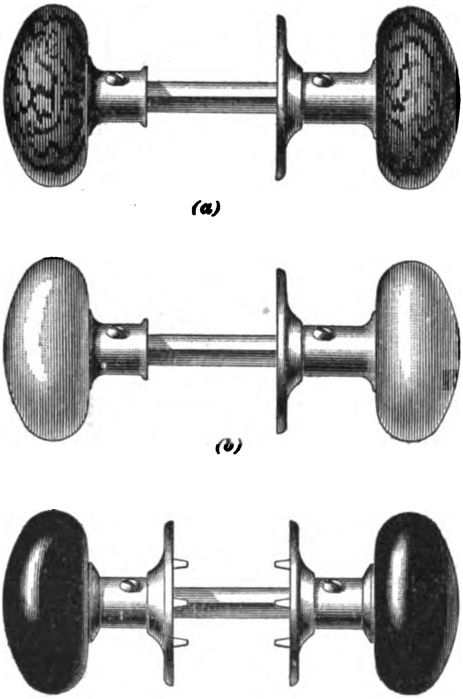
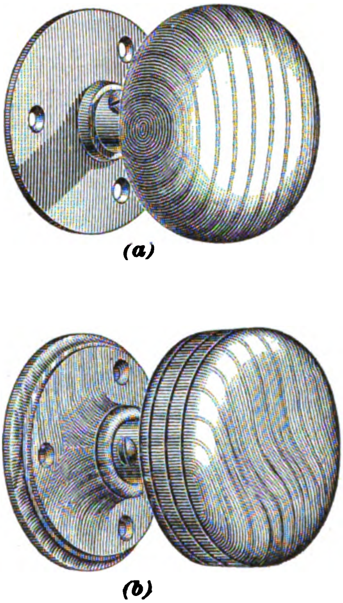

(a)
(b)
(c)

FIG. 58

52. Wooden Knobs.—Knobs made of wood are quite generally used. They are always turned from some hardwood, and are either stained or finished naturally. The wooden knob is usually forced on the shank by hydraulic pressure, and when securely fastened in this way makes a desirable and cheap knob. Many of the cheaper wooden knobs on the market are only glued or cemented to the shank, and, consequently, are not durable, as they pull off; they are therefore entirely undesirable. The mountings for the better knobs are made of iron, brass, or bronze, though they may be had with wooden roses. Mountings of wood, however, should not be used, as any severe side strain on the knob will split the rose with the grain of the wood. In Fig. 59 are shown two wooden knobs, the one at (*a*) having a metal rose, and the one at (*b*) a wooden rose.


(a)

(b)

FIG. 59

53. Cast-Iron Knobs. Cheap locks are usually provided with knobs made of cast iron, and, although they are strong and serviceable, they are seldom attractive. For finishing knobs of this kind, a bronze metal plating is usually employed. Cast-iron knobs are frequently made ornamental instead of plain. A typical cast-iron knob and rose are shown in Fig. 60.

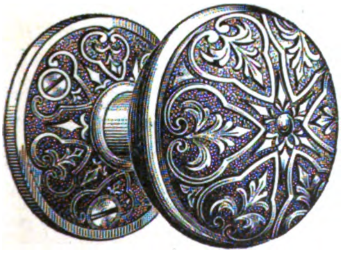


FIG. 60

54. Stamped and Spun-Metal Knobs.—Knobs made of sheet metal have lately come into extensive use, and they may be obtained in a large variety of designs and forms. Plain and ornamental steel knobs are illustrated in Fig. 61. Knobs ornamented in any style of design are in the market, and are artistic and usually well modeled.

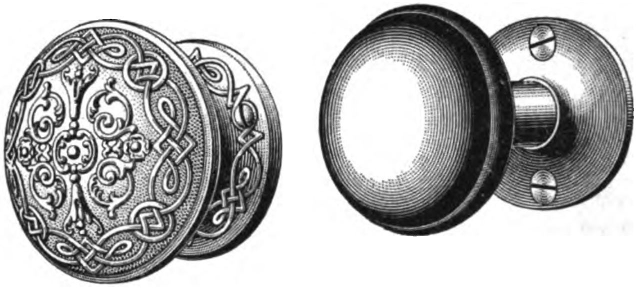


FIG. 61

55. Bronze or Brass Knobs.—Knobs of bronze or brass are always used in buildings of the better class, and all ornamental knobs of the higher grade are made of these materials. The best knobs are usually solid; that is, cast in one piece, with the exception that the shank is inserted. Others are made in composite form, consisting of a steel interior shell, or frame, over which is tightly drawn an external section, or covering, of wrought bronze or brass of substantial thickness. The completed knob, if properly made in this manner, is practically as strong as the hollow-cast knob and resists bruising or other injury.

56. Glass Knobs.—The most expensive knobs made are those of cut glass with metal mountings. Several knobs of this kind are illustrated in Fig. 62. Cut-glass or crystal-glass knobs are very costly, the price depending on the style and the amount of cutting required and on the grade of glass used. The new method of mounting glass knobs allows for adjusting the knobs to doors of varying thicknesses, and also gives the knobs a handsome appearance, making them both durable and reliable.

57. Styles and Sizes of Knobs.—The pottery knobs, such as the mineral, jet, and porcelain knobs, are made only in spheroidal and oval shapes. The spheroidal knobs are 2¼ inches in diameter, and the oval knobs 2½ in. × 1¾ in.

Cast-iron and stamped-steel knobs are made spheroidal and of the box pattern, with plain and molded edges, both styles of knobs being about 2¼ inches in diameter.

Bronze and brass knobs are usually spheroidal or ball-shaped, and are 2¼ and 2½ inches in diameter. They are also made oval and egg-shaped, these latter styles being provided in two sizes, namely, 3 in. × 2 in. and 2½ in. × 1¾ in. The same general dimensions obtain for wooden and glass knobs.

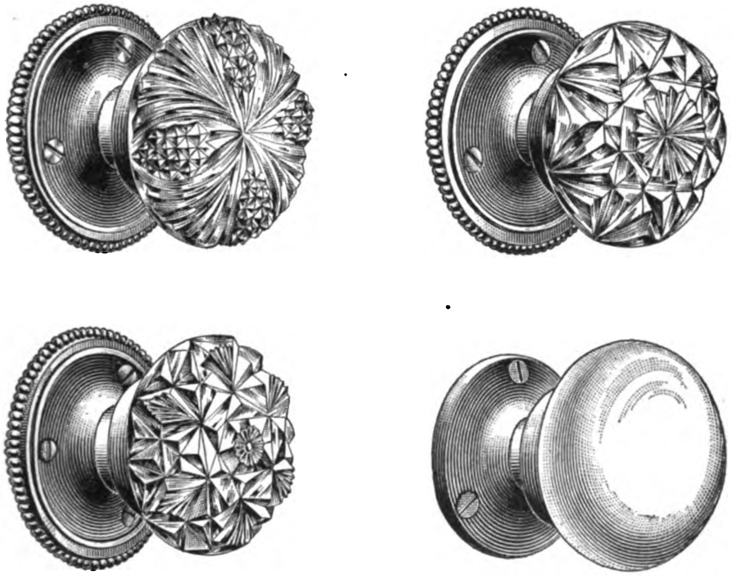


FIG. 62

58. Lock Spindles.—In supplying a pair of knobs, there is always included with them the *spindle*, which connects them and passes through the hub of the lock. The type of spindle generally used is the **common, or side-screw, spindle,** which is shown in Fig. 63. In this spindle, the knobs are secured by means of a knob screw passing through a hole in the knob and engaging with one of the threaded holes in the spindle. There are several holes in the spindle, so that the distance the knobs are apart may be adjusted properly. Should further adjustment be required, it is accomplished by placing thin washers at the end of the knob shank. This type of spindle is generally used with the cheap grades of trim, and should not be used in high-grade work.

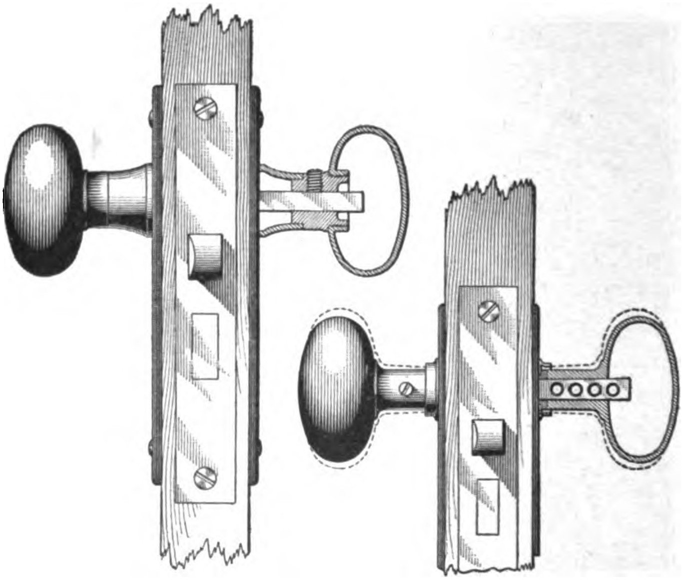


FIG. 63

There is a modern type of lock spindle, known as the "screwless" spindle, that permits the proper adjustment of the knobs without the use of washers and with less screws. These spindles overcome the general looseness and rattle found in the common type. A "screwless" spindle, known as the *Triplex*, is illustrated in Fig. 64. This spindle is a first-class device, and is constructed, as shown, of three parallel parts, triangular in section, which, together, form a square bar. To fasten the knob on this spindle, a setscrew in the knob bears on the center bar, and owing to their wedge form, the two side bars are forced apart and into frictional engagement with the spindle of the knob. The spindle itself is screwless, and there is nothing tending to loosen the set-screw, so that when once properly tightened, the knob will remain firm and in position on the spindle under all conditions of use. In some instances, this style of spindle has been condemned by owners and architects. This has been due largely to the fact that the mechanic did not set the screw tight against the spindle, thus allowing the knob to be easily pulled off. This is often caused by not using a screwdriver that exactly fits the head of the screw. When the knobs are put in place as they should be, this device always gives entire satisfaction.

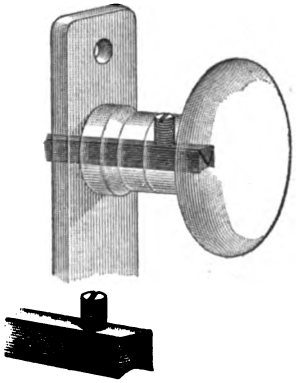


Fig. 64

There is another, though somewhat costly, type in the market, known as the **wrench spindle.** This spindle is illustrated in Fig. 65. As shown, the mechanism consists of a chuck, or vise-like arrangement, formed on the knob shank. When the nut *a* is screwed on the jaws *b*, the tendency is to grip the spindle securely, the latter being solid and without screw holes. This type of spindle allows perfect adjustment.

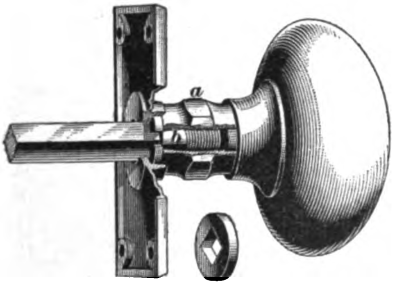


Fig. 65

Another type of knob spindle is the **swivel spindle.** This is used with front, vestibule, and other door locks that have stop-work, whereby the outside knob may be made operative or not, as desired. In order to accomplish this, the spindle is divided longitudinally, so that one end may rotate independently of the other.

The standard sizes of spindles for door locks, etc. are $\frac{5}{16}$ and $\frac{3}{8}$ inch square. Occasionally, spindles as large as $\frac{1}{2}$ inch square are used for large knobs or handles, such as would be used with massive lock trim. For thumb knobs and locks and latches of this character, spindles $\frac{1}{4}$ inch square are employed.

59. Key Tags for Hotel Use.—Considerable confusion is frequently created by hotel guests taking with them on departure the key to their rooms. Formerly, hotel managers sought to prevent this practice by attaching to each key a large tag of iron or brass, generally serrated on the edges and made so cumbersome as to practically preclude its being carried in the pocket. Subsequently, tags made of red fiber of large size became popular. The usual forms of these large tags, whether of brass or fiber, are illustrated in Fig. 66. The use of key tags, however, is gradually being superseded by having the name of the hotel and number of the room stamped plainly on the key bow, the stamped name of the house serving for its quick identification and return by mail. The latest and best development in this detail consists in attaching to the key bow, by means of a short chain, either an ornamental disk bearing the name of the hotel and the number of the room, or a small ball, the name and key number still being retained on the key bow. In either case, the short pendant serves for convenience in the use of the key, diminishes the danger of misplacing it, and, if well designed, contributes to its appearance.

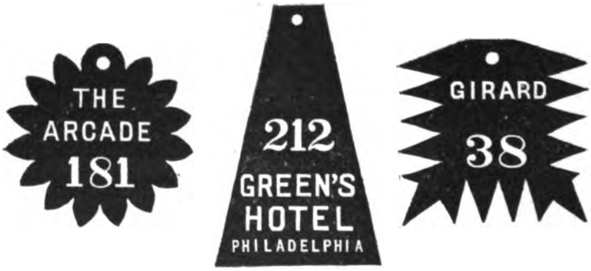


FIG. 66

WINDOW SASH HARDWARE

SASH TRIM FOR DOUBLE-HUNG WINDOWS

60. Sash Pulleys.—The pulleys for the counterbalancing of double-hung, or sliding, windows, while apparently unimportant pieces of hardware, are worthy of much consideration in their selection, and in the preparation of the specifications care should be exercised to provide the best pulley consistent with the character of the work. It is good practice to furnish the millmen with a sample of the pulleys that are to be used, so that the frame will be properly mortised to receive them when the sash are hung. By this method, the necessity of exposing the case to the weather during the erection of the structure is obviated.

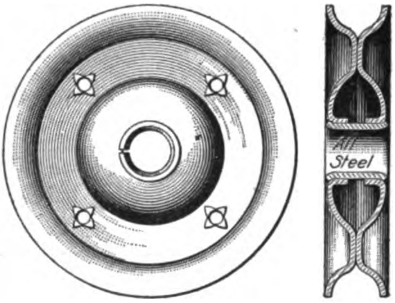


FIG. 67

The common grades of sash pulleys are rough and cheap, and may be used for unimportant work and light sashes. For heavier sashes and important work, however, a better grade of larger and heavier construction should be used. It is important in specifying sash pulleys to stipulate the size of the pulley and to specify the diameter of the axle; also to state whether brass or bronze wheels and bronze faces are desired. Pulleys are supplied in $1\frac{3}{4}$-, 2-, $2\frac{1}{4}$-, $2\frac{1}{2}$-, and 3-inch diameters. The required diameter of the pulley is determined by the thickness of the pulley stile and the diameter of the sash weight required to balance the sash.

The cases in which the pulleys are mounted in the cheaper grades are made of cast iron, while in the better grades they are made of stamped metal. High-grade pulleys constructed of stamped metal are also provided; these are put together either by riveting the two faces of the pulley or by electrically welding them. The construction of a built-up steel pulley is illustrated in Fig. 67. The cases enclosing the pulleys are made of cast iron, as illustrated in Fig. 68 (*a*), or they are constructed of stamped metal, as shown at (*b*). The ends of the facing of the case are made square, rounded, or auger-shaped, and are finished either rough, polished, or lacquered, or are faced with brass or bronze of any finish desired. The pulleys illustrated in Fig. 69 (*a*) are so constructed that the mortise in the frame may be readily formed by a special boring machine carrying three or four bits.

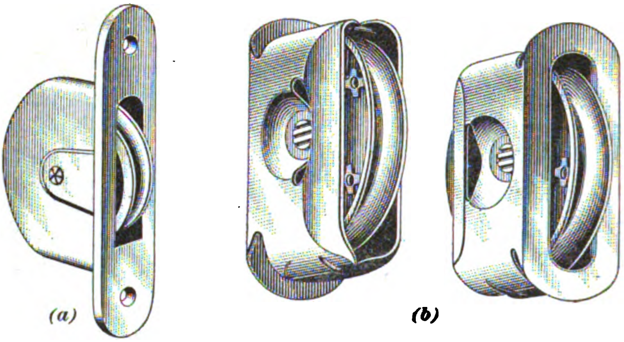
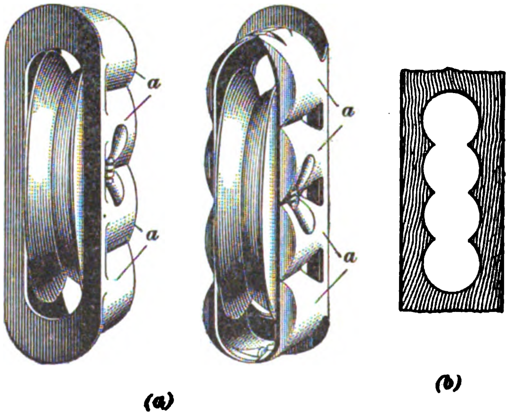

(*a*) (*b*)

FIG. 68

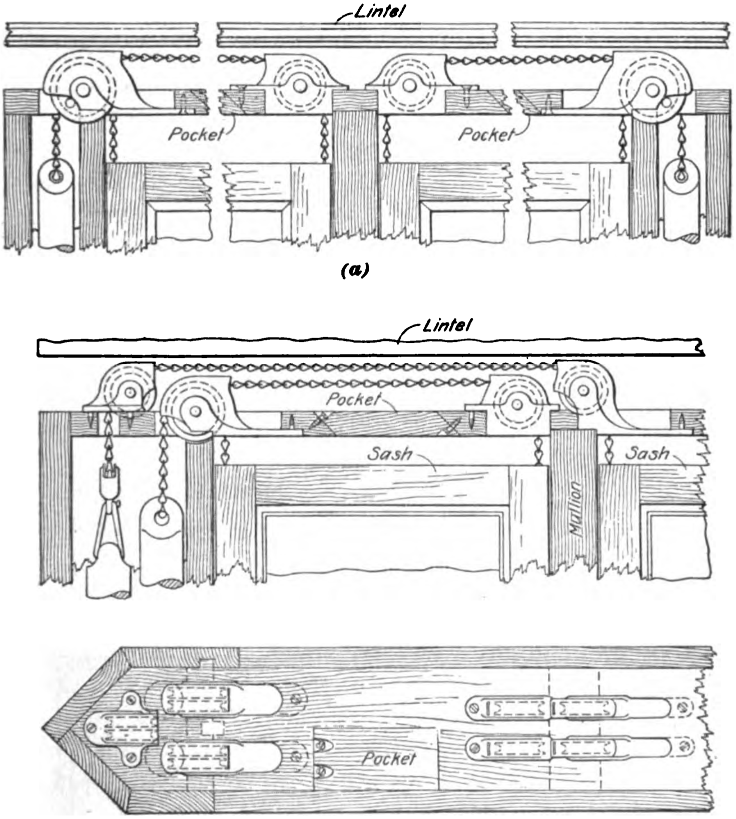


(*a*) (*b*)

FIG. 69

This machine bores holes of a size to fit the several cylindrical portions of the stamped-metal case, as at *a*, *a*, a diagram of the mortising in the frame being illustrated at (*b*).

The better grades of pulleys may be procured with semi-steel, brass, or bronze wheels, and with plain axles or with ball or roller bearings. In the cheaper grades of sash pulleys, the axles are formed of common wire, while in the better grades they are made of either steel or gun metal $\frac{3}{8}$ inch in diameter. In the best pulleys, the wheels are



(b)

FIG. 70

turned, to insure smoothness of motion, and are made with grooves for cord, ribbon, or chain. All steel pulleys built up as illustrated in Fig. 67 are of recent invention; they run smoothly, and are very easily applied. These pulleys are also made with ball or roller bearings, and may be obtained at a reasonable price.

There is a special type of sash pulleys that may be used for twin and triple windows, where it is necessary to form a narrow mullion between the windows. This pulley is known as the *Grant overhead sash pulley*, and is used as illustrated in Fig. 70. At (*a*) is a twin-window arrangement, showing the sash on the two sides double-hung, each sash being counterbalanced by means of one counterweight. By this means, the frame mullion between the two sashes can be made as narrow as 2 inches, which is an advantage where the maximum amount of daylight opening is desired. Frequently, in triple windows, the center sash, as well as the two side sashes, is made double-hung. In such a case, the arrangement of the overhead pulleys would be as shown in Fig. 70 (*b*). These pulleys provide a convenient means for arranging double-hung windows of this type, but sufficient room must be left in the head of the window to allow for the insertion of this pulley and the travel of the sash counterweights. The construction of this type of overhead pulley with roller bearings is shown in Fig. 71.

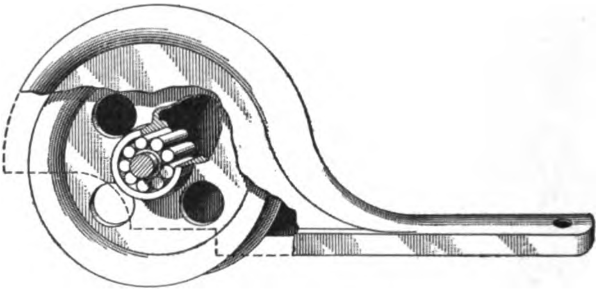


FIG. 71

61. Determination of Size of Sash or Frame Pulleys.—The architect's specifications should stipulate the diameter of the sash pulleys to be used in the work, and this item requires careful consideration. Where care is not exercised in this regard, either the pulleys will be so small that the weight will rub against the pulley stile, or they will be so large that the weight will rub the jamb casing on the opposite side of the pocket. Standard sash pulleys are made in sizes from $1\frac{3}{4}$ to 3 inches in diameter, varying by quarter inches. In determining the diameter of the pulley required for a particular window frame, a good rule is to multiply the thickness of the pulley stile by 2.25; thus, a $\frac{7}{8}$-inch stile would require a 2-inch pulley; a $1\frac{1}{8}$-inch stile, a $2\frac{1}{2}$-inch pulley; and a $1\frac{3}{8}$-inch stile, a 3-inch pulley. It is best to specify that pulleys for metallic frames shall be of the larger size, namely, 3 inches in diameter; and also that these pulleys shall have $\frac{3}{8}$-inch axles.

62. Sash Cords and Chains.—The **sash cords** by which the sashes are attached to the counterweights in double-hung windows are usually furnished by the carpenter, and are so specified. However, they may be specified under hardware. The specification for the sash cord should state both the size and the maker's name, and for good standard work *Sansom Spot* or *Silver Lake* sash cords are the best that can be procured. Table VI will be found convenient in

TABLE VI

STANDARD SIZE OF SASH CORD FOR PULLEYS

Size No.	Diameter of Cord Inch	Average Weight per Dozen Hanks Pounds	Average Number of Feet per Pound	Heaviest Weight to Be Used Pounds	Smallest Pulley to Be Used Inches
6	$\frac{3}{16}$	18	66	5	$1\frac{1}{2}$
7	$\frac{7}{32}$	22	55	15	$1\frac{3}{4}$
8	$\frac{1}{4}$	27	44	25	2
9	$\frac{9}{32}$	33	36	35	$2\frac{1}{4}$
10	$\frac{5}{16}$	44	27	45	$2\frac{1}{2}$
12	$\frac{3}{8}$	60	20	55	3

determining the diameter of the cord and the consequent size by number, as well as the size of the sash pulley.

Sash chains are made in the form illustrated in Fig. 72, and may be had either in steel, red metal, or bronze. The sash chains in the market are usually made in four sizes, being numbered from 0 to 3. The makers, however, have no agreement regarding these standards, so that the numbering is not uniform; one manufacturer's No. 0 chain may be his heaviest make, while a chain of the same number furnished by another maker may be the lightest chain that he manufactures. In order to provide against this discrepancy when specifying, it is well to name the maker of the chain. The lightest sash chain will support sashes weighing from 40 to 75 pounds, while the heaviest will carry sashes that weigh from 150 to 250 pounds.

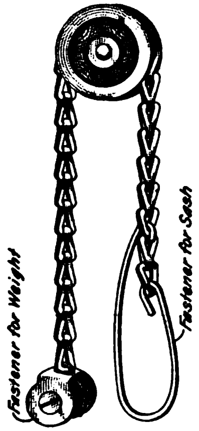


FIG. 72

63. Sash Balances.—By the use of **sash balances,** one of which is shown in Fig. 73, there is no necessity for weight boxes, counterweights, etc. The contrivance illustrated has been manufactured for many years, and the original intention was to have it displace the sash pulley, cord, and weight for double-hung windows. Installing spring sash pulleys costs more than the older method of hanging by means of counterweights. They are constructed with a long, spiral spring enclosed by a drum, on which the tape *a*, Fig. 73, winds and thus raises the sash. The coil spring in this balance

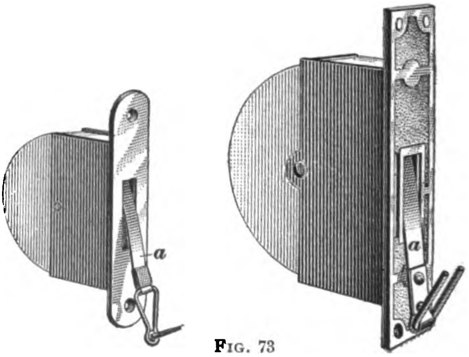
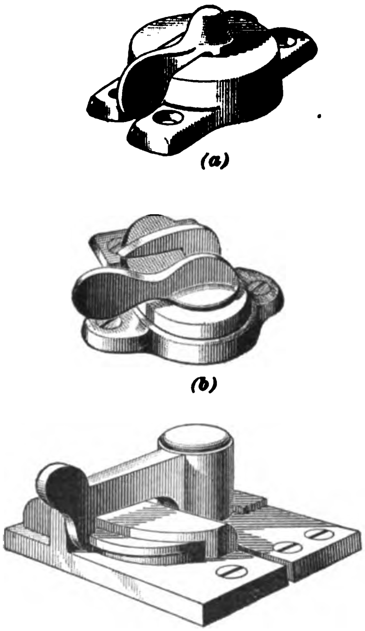


FIG. 73

is made of either light or heavy material, according to the weight of the sash it is intended to counterbalance. They are seldom used, however, except where there is insufficient room for sash weights. The steel tape is liable to be twisted and broken by jarring in operating the sash, and for general use it has been found that the most positive action is secured by pulleys and weights.

64. Weight of Sash and Glass.—In estimating the weight of window sash, in order that the size of the counterweights or of the spring counterbalance may be determined, the weight of the glass per square foot may be taken as follows: Plate glass, 3½ pounds; double-thick glass, 1⅓ pounds; and single-thick glass, 1 pound. To find the weight of the wooden sash, add together the height and the width of the sash, in feet, and multiply by 2.1 for 2¼-inch sash, by 1.67 for 1¾-inch sash, and by 1.33 for 1⅜-inch sash. The several sizes of sash given indicate the thickness of the sash frame. While these data for determining the weight of sash are not exact, they are sufficiently accurate to fix the size of the sash cords and pulleys and to estimate the weight required to counterbalance them. The best practice in counterbalance sashes, however, is to weigh the sash after it has been glazed; in this manner the exact weight and size of the counterweights required can be determined. The approximate weights of ordinary glazed sash are usually given in the catalogs of manufacturers of sash weights, pulleys, etc., and will be found convenient in determining the approximate weight of sash weights without making the calculations just described when estimating.

65. Sash Locks, or Fasts.—There are many different makes of **sash locks** for double-hung sash in the market. In Fig. 74 are shown several of the older type of sash locks that have been used extensively. The lock shown at (*a*) is known as the *Champion;* that at (*b*), as the *Ives*, and that at (*c*), as the *Boston*. This type of sash lock, the construction of which is apparent from the illustration, has given satisfaction for a number of years.



(a)

(b)

(c)

FIG. 74

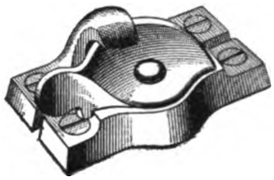


FIG. 75

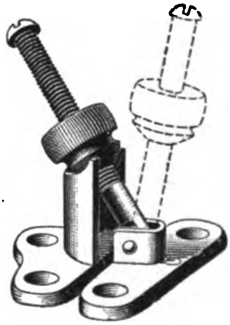


FIG. 76

A newer type of sash lock is that illustrated in Figs. 75 and 76. In Fig. 75 is shown a sash lock known as the *Fitch*. This lock is made by several manufacturers, and can be procured in all finishes of iron for the cheaper class of buildings, and also in bronze metal for high-class work. It is composed of a helical cam, which is fastened to the top of the meeting rail of the lower sash and engages with a hook, or lug, that is secured to the bottom of the upper sash. The operation of this fastener is rapid, and the rotary movement draws the two sashes together horizontally and forces them in opposite directions vertically. In this way, it holds the sash fast and prevents rattling and air leaks. It also has an advantage in that it cannot be moved by inserting a knife blade between the sashes from the outside. The *Yale screw sash fast* illustrated in Fig. 76 is an excellent piece of hardware. It accomplishes the same results as the Fitch lock; namely, drawing the sash together by the tightening of a thumb nut on a fine-pitched screw. This nut operates against a semicircular-shaped upright hook, or lug, on the lower sash, thus developing great pressure in the desired direction. While this sash fastener takes somewhat longer to operate than the Fitch, it repays by providing greater security.

66. Sash Lifts.—While **sash lifts** are not required for the cheapest work, as the window can be raised by pushing against the parting rail or against the mullions, nevertheless they are made to sell at such reasonable prices that it would seem advisable to place them on the lower sash of all buildings, no matter how unimportant.

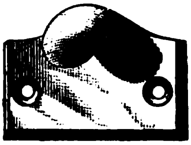


FIG. 77

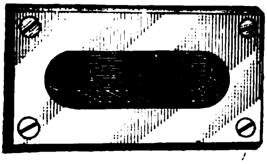


FIG. 78

The common type of sash lift illustrated in Fig. 77 is known as the *hook sash lift*. This lift is extensively used, and can be procured in any grade or weight, in either cast iron, steel, or bronze metal, and in any finish desired.

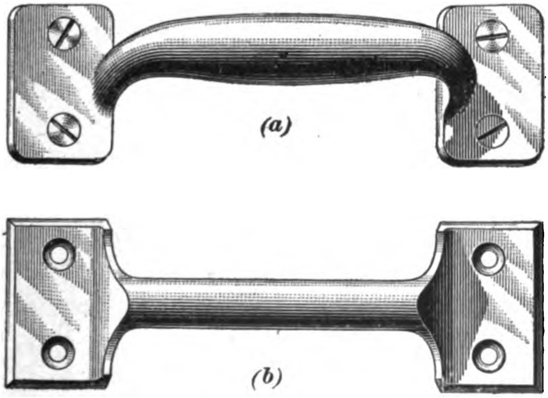
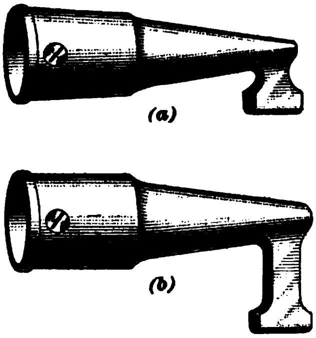


FIG. 79

The *flush sash lift*, the general type of which is shown in Fig. 78, makes a better appearance than the hook lift, and is considerably stronger, from the fact that the casing forming the grip is let into the lower rail of the sash, and the strain is taken by this, rather than by the screws. These lifts are made in either steel or bronze, and in all finishes; they can also be had ornamented to correspond with the lock trim.

For heavy sashes, such as those in public and commercial buildings, the *bar sash lift* illustrated in Fig. 79 is the best. This type of lift should always be used for heavy sash. A sash lift similar to the type shown at (*a*) is sometimes fastened to the under side of the meeting rail of the upper sash for the purpose of lowering the sash.

67. Sash Sockets and Pole Hooks.—In buildings having high ceilings, where the top sash is some distance from the floor, as is likely to occur in institutions, schools, and factories, it is necessary to provide "pull-down" poles for the purpose of raising and lowering the upper sash. The hooks used on the ends of such poles, which are made of some tough wood, are as illustrated in Fig. 80. Unless the upper sash is furnished with metal plates that have a hole, or aperture, the pole will be used against the mullion or upper rail of the window sash and thus mar the woodwork. The plates, or metal sockets, to engage the sash and pull-down poles, are illustrated in Fig. 81. They may be had in all metals and finishes and in several sizes.


(a)

(b)

FIG. 80

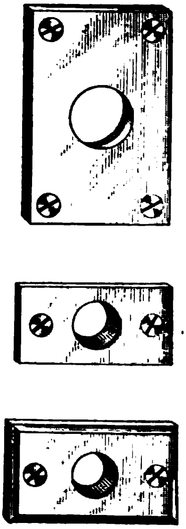


FIG. 81

68. Stop-Screws.—The *stop-bead screws*, or *washers*, or, as they are more commonly known, the **window-stop**, or **bead, adjusters**, types of which are illustrated in Figs. 82 and 83, are necessary hardware adjuncts to the window trim for buildings of the better class. In ordinary work, these stops are secured to the frame by nailing, but when they are fastened in this manner, the stop-beads are disfigured if it is necessary to remove them. A cheap and good way of fastening these stop-beads is to use ordinary round-headed screws. While these adjusters answer the purpose very well, they do not allow for the adjustment of the stop-bead sidewise, so as to take up any shrinkage that might occur in the sash and prevent it from rattling, as well as making it air-tight.

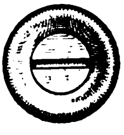


FIG. 82

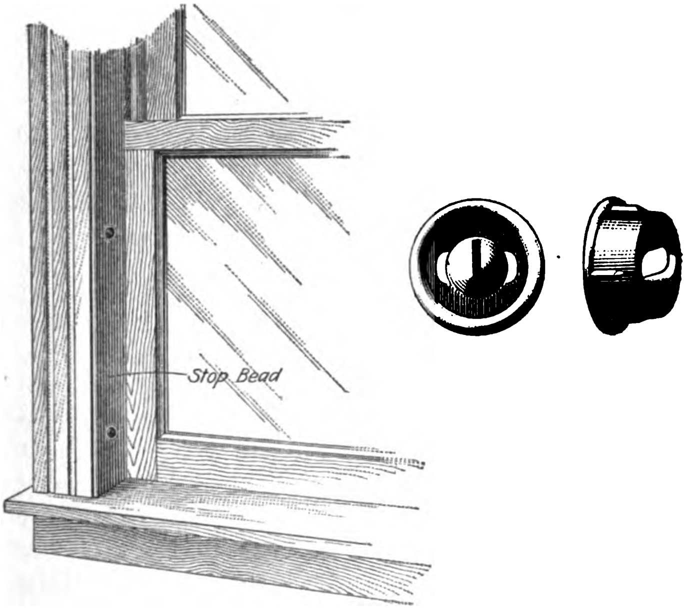


FIG. 83

To overcome this deficiency, a **surface washer**, as illustrated in Fig. 82, was originated. The surface washer was ordinarily made about $\frac{5}{8}$ inch in diameter, and was provided with one large hole about $\frac{3}{8}$ inch in diameter or with two smaller holes placed side by side horizontally across the stop. By this means, the proper adjusting of the stop-bead was provided for, the washer covering the opening, or hole, through the stop. However, the defect in this method consisted in the marring of the finished stop when adjustment was required, for the washer left its imprint on the woodwork, and, when shifted, this would show.

The best form of stop-bead washer is illustrated in Fig. 83, and is known as the *Taplin adjusting screw* and *countersunk cup washer.* This device is composed of a sunken, or cup, washer with a slotted or horizontal hole in its base frame, so as to allow about a $\frac{3}{16}$-inch adjustment. This adjustment, as can be clearly seen from the figure, is made without marring, or disfiguring, the stop-bead in any way. These countersunk washers may be had in bronze or steel, those made of steel being finished to match the hardware, as desired.

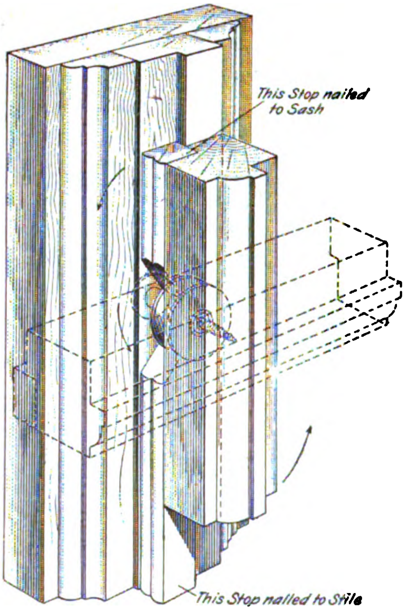


Fig. 84

TRIMMINGS FOR PIVOTED AND CASEMENT SASH

69. Sash Centers. When a transom sash is hung at the top or the bottom, regular hinge butts may be used; but where a sash is pivoted at the center, either on the sides or at the top and bottom, a pivoted arrangement, termed a **sash center,** is needed. For large sash or heavy transoms, and especially for those that are exterior sash, the rabbeted center should be used. This type of center is illustrated in Fig. 84; its construction gives great strength and completely closes the joint against light and water.

An excellent type of center, known as the *Howarth sash center*, is illustrated in Fig. 85, the method by which it is attached to the frame and sash being clearly indicated. By this arrangement, the two parts of the center fold, or butt, against each other and form a tight joint, the stop-bead for the sash at the top and bottom being arranged as indicated at *a a*.

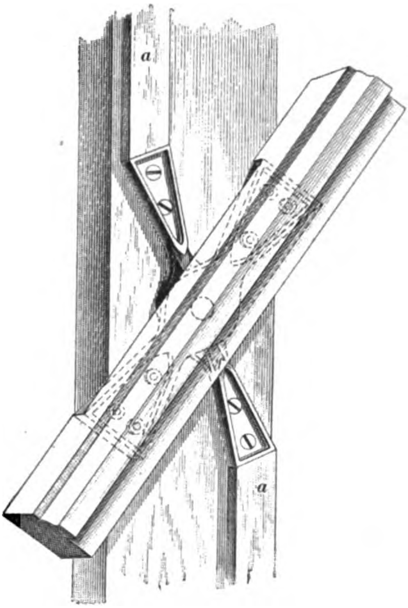


FIG. 85

There is a sash center, known as the *Tabor*, that is constructed as shown in Fig. 86. This center is used for very large sash that are vertically pivoted; that is, arranged with a center at the top and bottom. Such sash as these are used extensively in office buildings, because, by their use, the entire window may be thrown open at one time. The Tabor device consists of a special sub-sill, which engages with a ribbed joint strip placed on the bottom of the sash. By this means, a weather-tight joint is secured, and the sash is firmly locked in a closed position. By throwing a lever, the sash is raised above the astragal, or sub-sill, and can then be operated. The top rail is supplied with a filling strip having an irregular joint at the intersection with the sash, and is held firmly by a coil spring encircling the top pivot.

In Fig. 87 are shown several sash centers of the common type. These possess no particular merit, but are much used for common work.

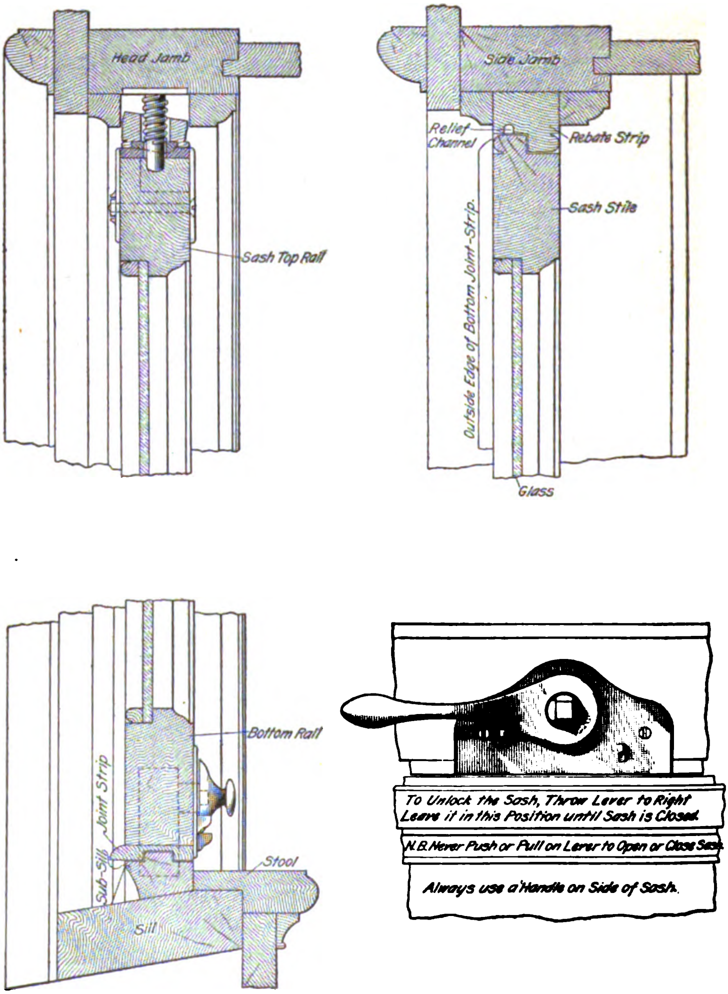

Head Jamb
Sash Top Rail
Side Jamb
Relief Channel
Rebate Strip
Sash Stile
Outside Edge of Bottom Joint-Strip
Glass
Bottom Rail
Joint Strip
Sub-Sill
Stool
Sill
To Unlock the Sash, Throw Lever to Right
Leave it in this Position until Sash is Closed.
N.B. Never Push or Pull on Lever to Open or Close Sash.
Always use a Handle on Side of Sash.

FIG. 86

70. Transom Lifts.—The **transom lift** illustrated in Fig. 88 is distinctly an American device for operating and fastening the transom lights over doors. This device is used extensively in hotel and office buildings. It is made in various styles and sizes necessary to meet the several requirements. The transom lift consists of a vertical sliding rod that is placed on the door jambs, as at *a*, with an arm at the top connecting it with the sash, as at *b*. Near the bottom is a clamp, or grip, that holds the bar *a* in any desired position. By a vertical movement of the rod, the sash is caused to swing. Transom lifts may be had for transom sashes that are pivoted at the center or for those which are hinged at the top or the bottom. At (*a*) and (*b*) in Fig. 88 are shown the types of transom lifts for center-pivoted sash; the former arranged so that the sash pitches outwards, while in the latter the sash pitches inwards. At (*c*), the device is shown where the sash is hinged at the top, while at (*d*) the sash is hinged at the bottom. The several kinds of transom lifts made by the various manufacturers are practically alike, except for variations in the form of the grip, or clamp. The range of sizes and quality of transom lifts is large. The commercial article may be obtained in steel, copper or bronze plated, or in bronze or brass. They are made in $\frac{1}{4}$-, $\frac{5}{16}$-, $\frac{3}{8}$-, and $\frac{1}{2}$-inch sizes, the size being determined by the weight of the sash and the degree of rigidity and solidity

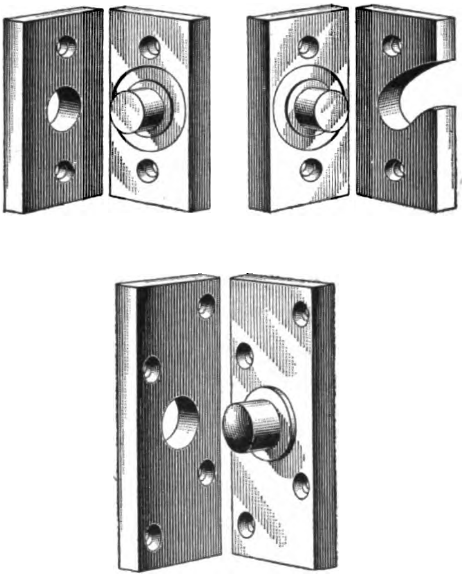
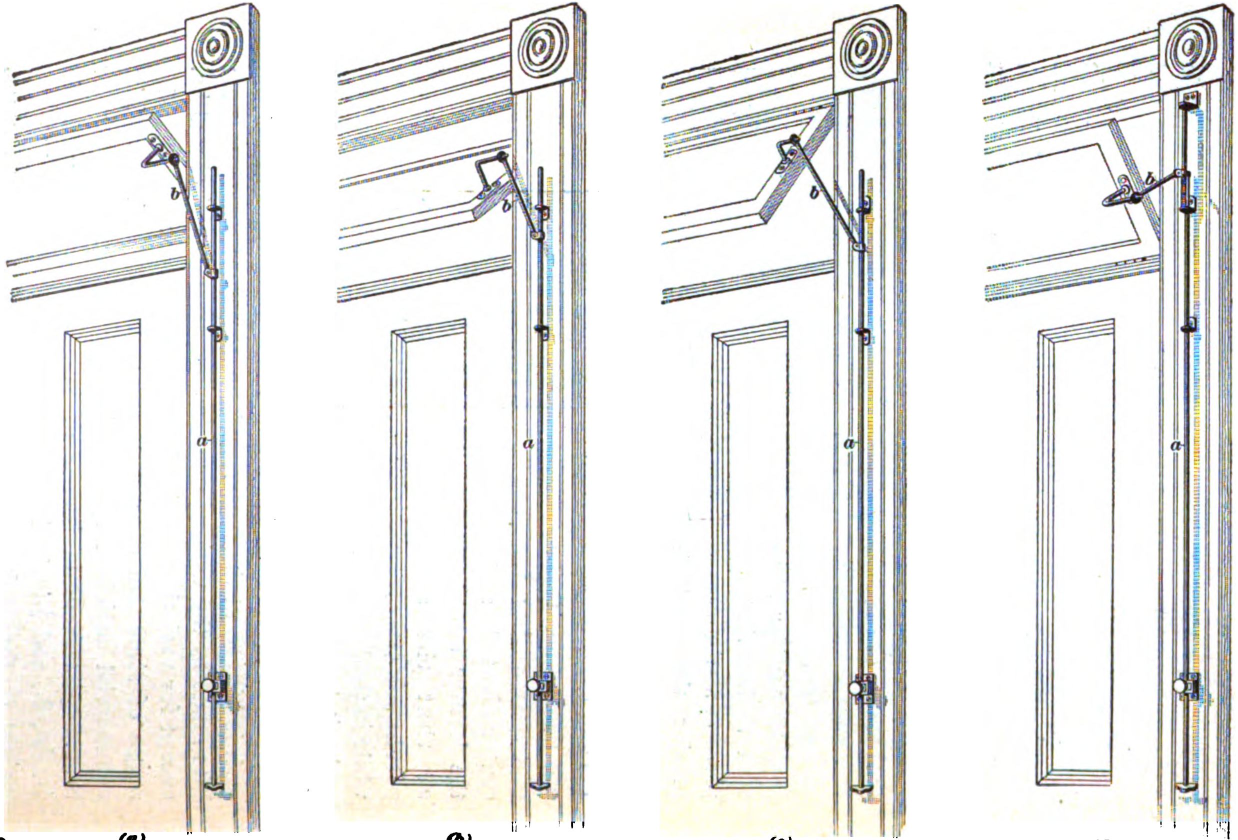


FIG. 87



(a) (b) (c) (d)

Fig. 88

desired to be obtained and expressed. For good work, the $\frac{3}{8}''$ and $\frac{1}{2}''$ diameters are used. The rods may be obtained in lengths of from 3 to 12 feet. In specifying or ordering transom lifts, the rod should always be sufficiently long to reach within 5 feet of the floor.

71. Transom Catches.—In Fig. 89 are illustrated types of **transom spring catches, or bolts.** These devices are provided in the several forms shown to meet various conditions. Those shown at (*a*), (*b*), and (*c*) have a ring, or eye, in the handle, to which an operating cord may be suspended, or into which a pull-down hook may be inserted, to operate the sash. The transom catch at (*d*) is made expressly for operation by means of a pull-down hook. In very wide windows, for the purpose of limiting the opening of the sash, these catches should be used in conjunction with chains instead of with transom lifts.

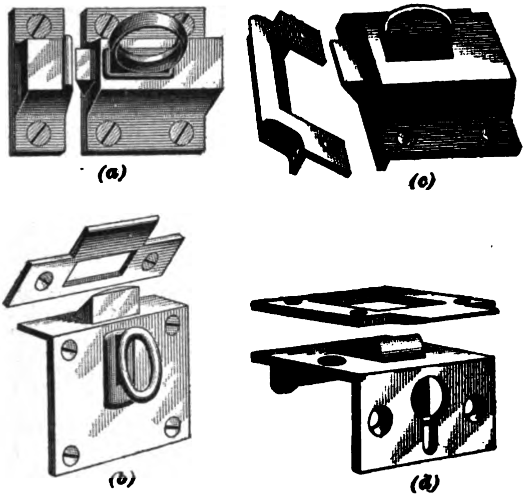


FIG. 89

72. Transom Chains.—In Fig. 90 are illustrated several types of **transom chains.** The chains shown at (*a*) and (*b*) are suitable for sashes weighing not more than 25 pounds, while that at (*c*) is sufficiently strong for sashes weighing over 25 pounds. These chains are fastened to cleats furnished with countersunk screw holes for securing readily to the frame and sash. When the sash is hinged at the bottom, these chains are used to limit the opening of the sash. They are sometimes employed as an additional guard, to prevent the sash from falling in case the sash lifter becomes broken. The ordinary lengths of sash chains range from 8 to 24 inches, the latter length being sufficient for the opening of the largest sash.

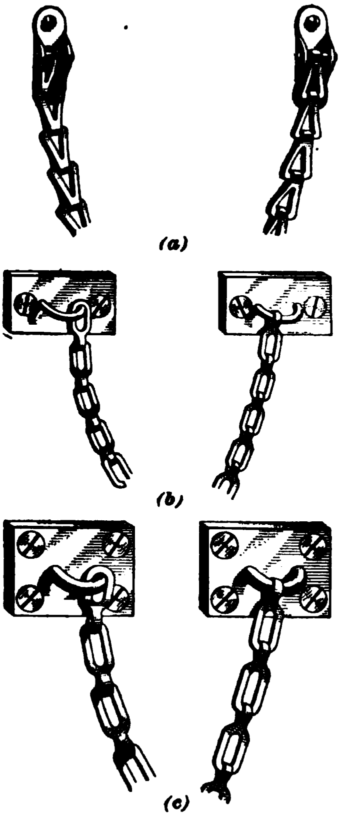


FIG. 90

73. Casement Trim. The term *casement* applies properly to any hinged sash. It is, however, usually limited to windows that have a sill set some distance above the floor. Where the casement sash extends to the floor, the term *French window* is generally applied, although frequently the terms are confused. In designing casement windows, the details of the hardware should be such that the casements can be made weather-tight; and in laying out the full-sized details for the mill-work for a casement sash and frame, the available hardware should be studied, so that the woodwork may be arranged to conform to it.

74. Casement Bolts and Fasts.—Casement sash may be provided with any good form of top and bottom bolts or hinged sash fasteners, but these should be supplemented by a good latch or cupboard catch at the center. Special **turnbuckles**, or **casement fasts**, constructed as shown in

Fig. 91, are on the market. All of the catches shown will securely fasten the sash, but the types shown at (*a*) and (*d*), Fig. 91, will draw the sash tightly against the frame when the buckle, or fast, is drawn in place. In countries where casement sash are in general use, the necessary fastenings, including the top and bottom bolts, are embodied in one structure, as described in the following article.

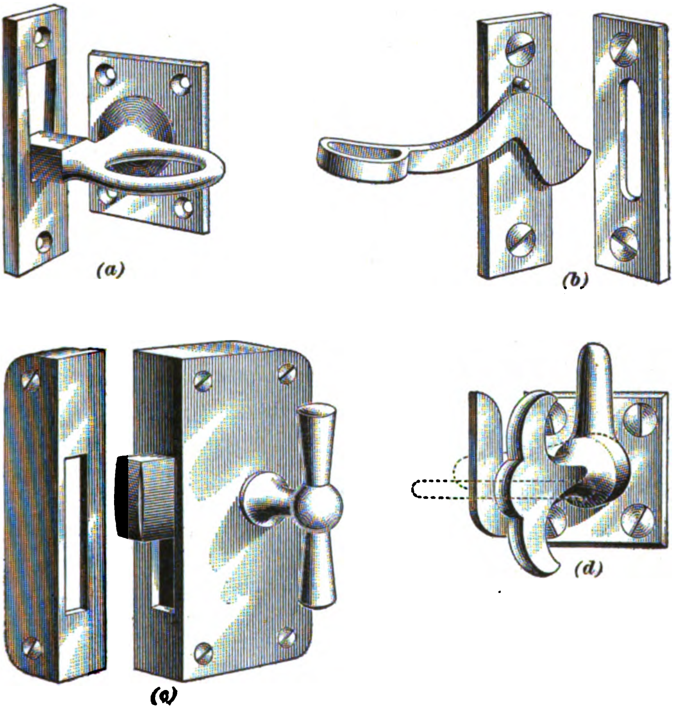


FIG. 91

75. Cremorne Bolts.—In the best work, the **Cremorne bolt** is used for casement windows. This device consists of a vertical rod divided at or about the middle of its length, thus making two pieces, and is operated by a knob, or handle, at that point. Types of ornamental Cremorne bolts are illustrated in Fig. 92. As shown, the upper and lower ends of the rods, or bolts, slide vertically and in opposite directions, being operated by the turning of the knob, or handle. These bolts are furnished with suitable strikes, either of the plate or the box form, which are attached to the window at the top or the bottom. Since the ends of the bolts are beveled, they press the two sashes tightly together and against the sash frame when they are thrown in. A single movement of the knob, or lever handle, is sufficient to release both bolts.

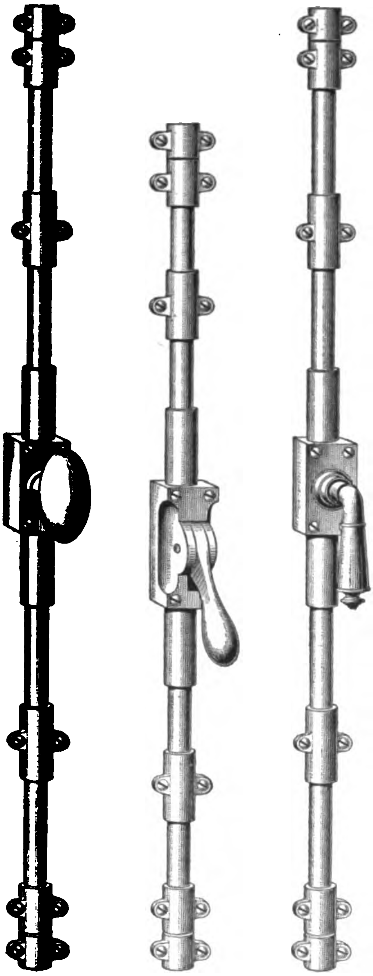


FIG. 92

76. Espagnolette Bolts.—In Fig. 93 is shown the **Espagnolette bolt,** which is similar in construction to the Cremorne bolt. This bolt consists of a vertical rod, but instead of being in two pieces, as in the Cremorne bolt, it is in one piece. This rod has hooks at each end, and, by a rotary motion, engages pins, or plates, in the window frame and thus draws the sashes together and against the frame. These bolts are usually operated by a pendant handle, which, when lifted to a horizontal position, will release the rod so that it may be rotated to fasten or to release the sash. For very high sash, a supplemental design may be used by providing a tapered hook on the opposite sash for the pendant. The Espagnolette bolt is usually heavier than the Cremorne and exerts more power in forcing the sashes against the frame; it is also more expensive. Both bolts, however, are available for use on doors as well as on windows, and lend themselves admirably to decorative treatment, as shown in the illustrations.

The same care should be exercised in the selection of these bolts as for other hardware, and when ordering them, full-sized details should accompany the order, showing sections through the top rail and head-jamb, the bottom rail, the sill, and the lock stile. The exact measurement of the height and the width of the openings should also be given, and the information should state whether the sash swings inwards or outwards. The hand of the active leaf, as well as the height of the handle from the floor, should also be given. In Fig. 94 are shown sections through a casement sash, illustrating the conditions requiring the use of Espagnolette bolts, and, as just stated, sections similar to these should be furnished the dealer, or manufacturer, so that these bolts will fit the construction when they are delivered.

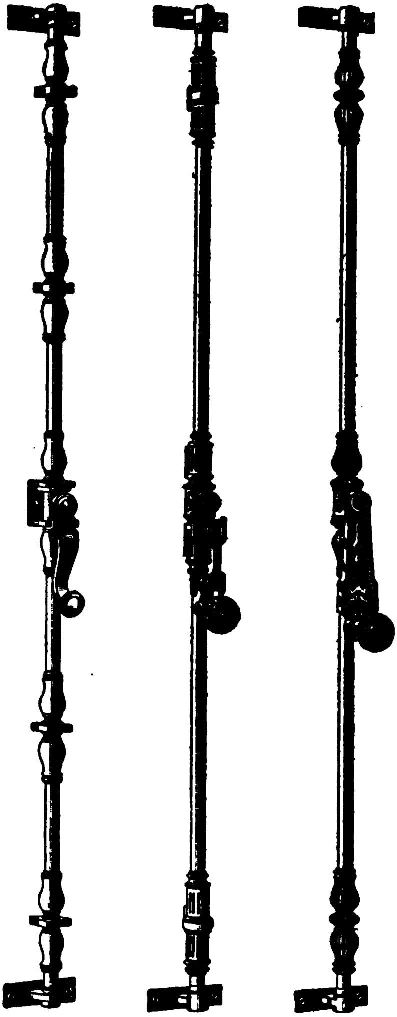


FIG. 93

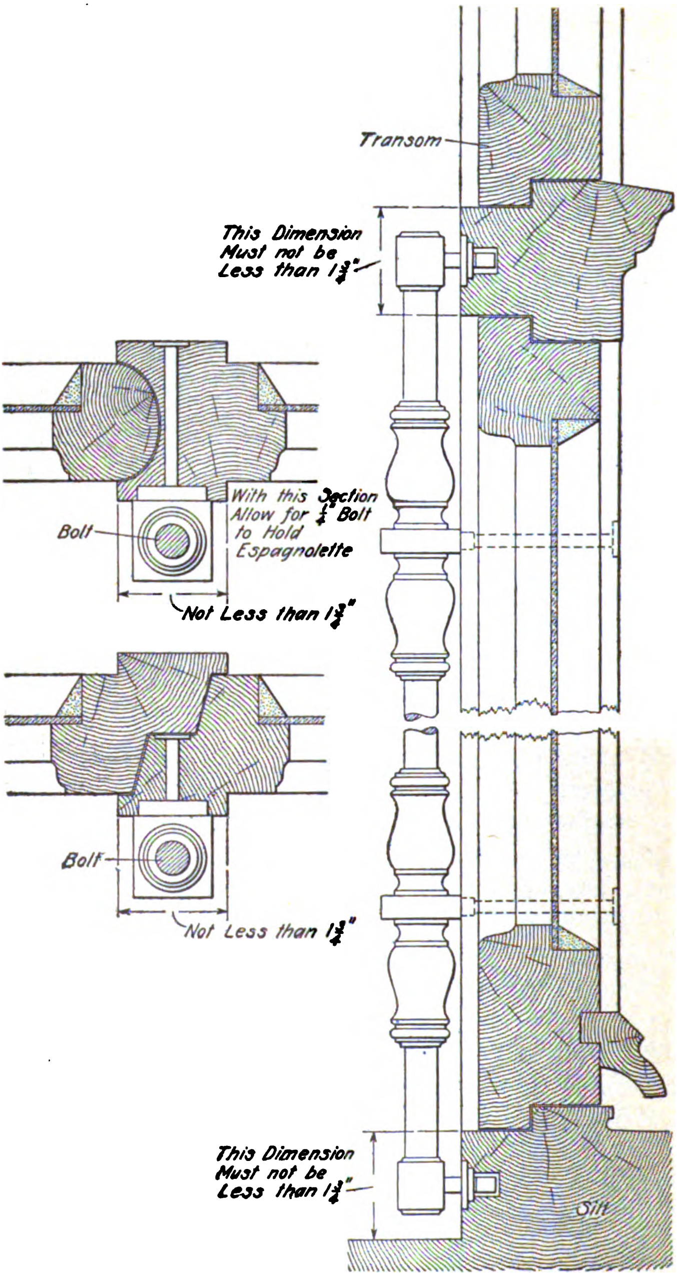

Transom
This Dimension Must not be Less than 1¾"
With this Section Allow for ½" Bolt to Hold Espagnolette
Bolt
Not Less than 1¾"
Bolt
Not Less than 1¾"
This Dimension Must not be Less than 1¾"
Sill

Fig. 94

77. Casement Adjusters.—In order to hold pivoted or hinged sash in a partly open position, it is necessary to use **casement-sash adjusters.** These adjusters, and the method of applying them, are illustrated in Fig. 95. In this figure is shown the adjuster applied to a sash pivoted at the top and the bottom, but the device can as well be applied to a casement sash hinged at the sides.

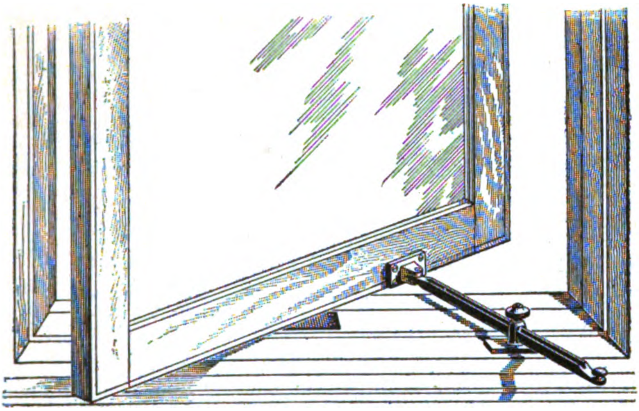


Fig. 95

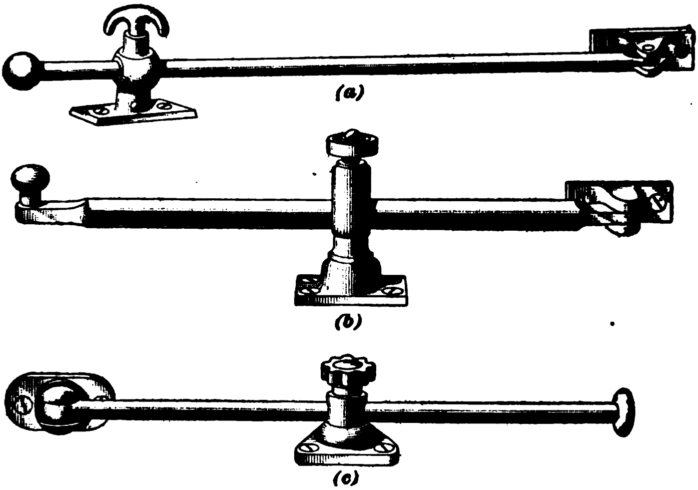


Fig. 96

There are many forms of casement-sash adjusters, the common types being illustrated in Fig. 96. They are arranged for sash that open either inwards or outwards, and may be applied to either pivoted or hinged sash. Most casement-sash adjusters usually consist of a rod or a bar attached to the sash by a hinged or pivoted joint. The rod passes through a clamp on the frame, or sill, and this rod, when the clamp is tightened, holds the sash firmly in any desired position.

78. Window and Shutter Operating Devices.—The **sash-operating device** is provided for the purpose of controlling a number of sash in a line by one piece of mechanism. Frequently, divided sashes are arranged side by side in skylights, clearstories, and monitors. These windows are usually some distance from the floor, and the operating device must be so arranged that it can be worked conveniently. The device illustrated in Fig. 97 is known as the *Lovell window and shutter operating device*, and consists of two longitudinal sections of pipe shafting *a* connected to cog racks *b* at the end. These cog racks in turn engage with a cog, or wheel, shaft *c*, as indicated in the figure. Connecting arms *d*, with swivel joints at each end, are arranged between the pipe shafts and the sash. The ends connected to the sash are secured to the same by means of plates and wood screws, and the swivel joint at the other end is provided with a sleeve, or socket, that is secured to the pipe shafts with a setscrew. The commendable feature of this device is that it is operated by a straight push or pull of the arm, instead of a twist, as in some other devices on the market. When the chain, or rope, around the large chain wheel is pulled, the cog is turned, and as it engages the racks, it thrusts one pipe horizontally in one direction and the other in an opposite direction. By this means, the connecting arms to the sash approach one another and lengthen the distance between the shafting and the sash, which movement tends to push the sash open, the sash being closed by the opposite operation. By this device as much as 500 feet of sash may be operated by one wheel, or "power," as it is called. This chain wheel, or power, may be located either in the center or

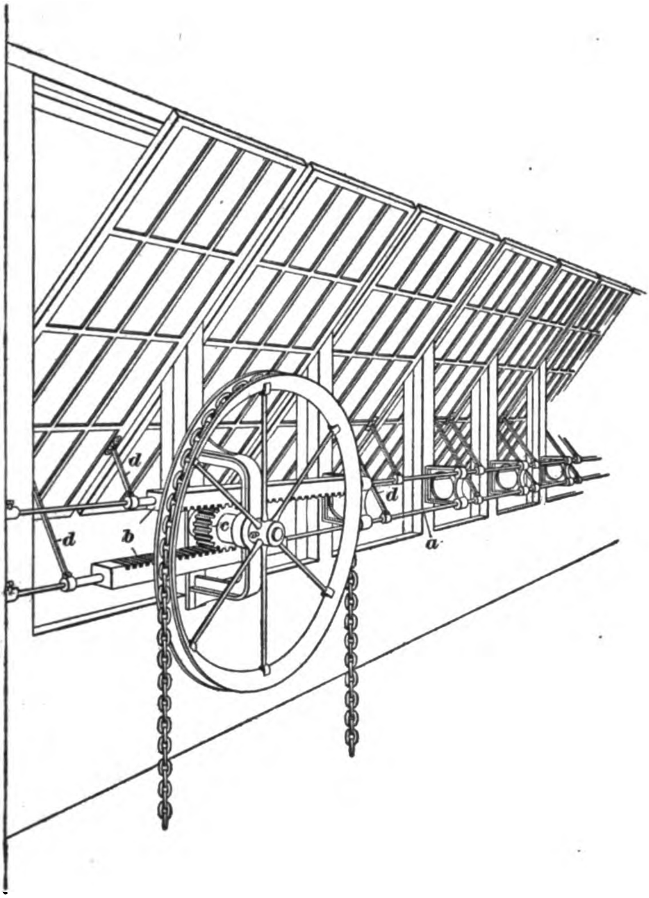


FIG. 97

at the terminals, and by careful adjustment will simultaneously close all the sashes tight against the frame.

DOOR HARDWARE AND ITS APPLICATION

79. Door Pulls.—In Fig. 98 are illustrated two well-known types of door pulls. The pull shown at (*a*) consists of a handle that is usually mounted on a plate and attached to either storm or single-acting doors, although, occasionally, this type is used on double-acting doors with the word "push" or "pull" inscribed on the plate. When used on double-acting doors, the door pull has a tendency to obviate the habit of persons placing their hands on the moldings near the glass when operating the door, but is subject to the objection of inviting a pull to open the door even with the word "push" inscribed on the plate.

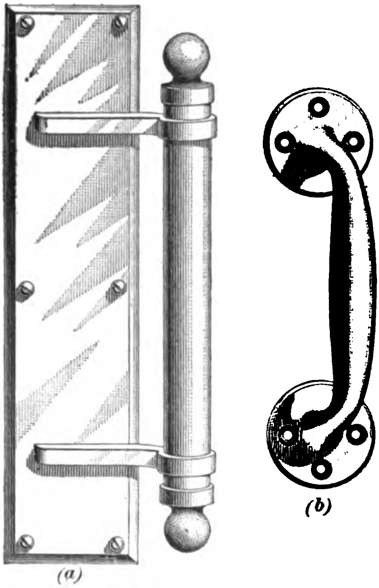


FIG. 98

Door pulls are made in various metals, both in plain and ornamental design, some of the latter being very elaborate, as will be observed from Fig. 99.

80. Kick Plates.—A **kick plate** is a modern device that may be applied to the bottom of doors to protect the woodwork from injury and wear, being used chiefly for double-acting doors and doors of public buildings. These plates are frequently made of sheet metal, but are much handsomer when made of cast metal and ornamented to harmonize with other metal work of the door.

Kick plates should completely cover the bottom rail of the door, but if cost is the controlling factor, they may be cut down in height so that a margin of wood the same width as

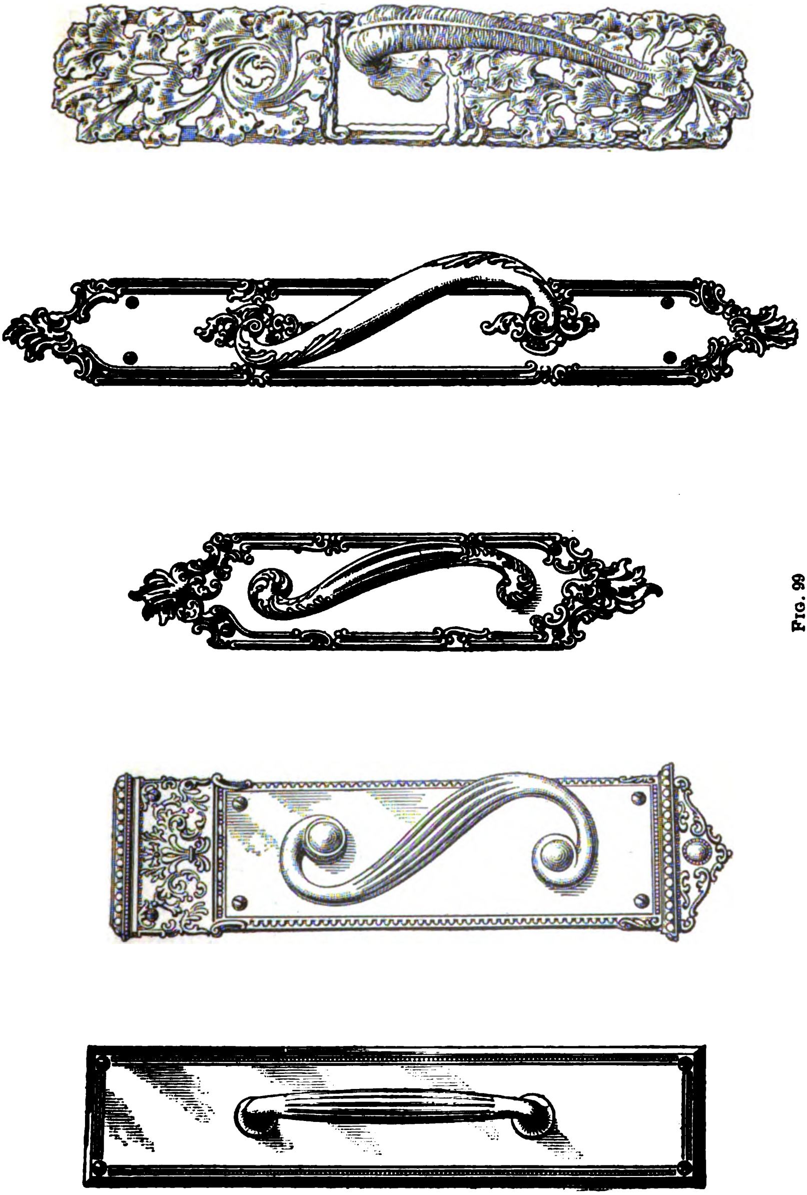


Fig. 99

the side, or lock, stile shows above the plate. For instance, if the bottom rail is 12 inches in height and the stile is 5 inches wide, the kick plate should be 7 inches high. In all cases, kick plates should extend the full width of the door, allowing enough margin, when used on double-acting doors, for the rounding of the edges. When used on single-acting doors having rabbeted jambs, the rabbet of both jambs should be deducted from the length of the kick plate. A typical kick plate of plain pattern is shown in Fig. 100. Such plates are generally sold at a square-inch price.

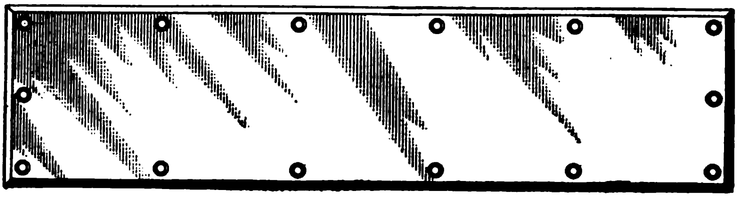
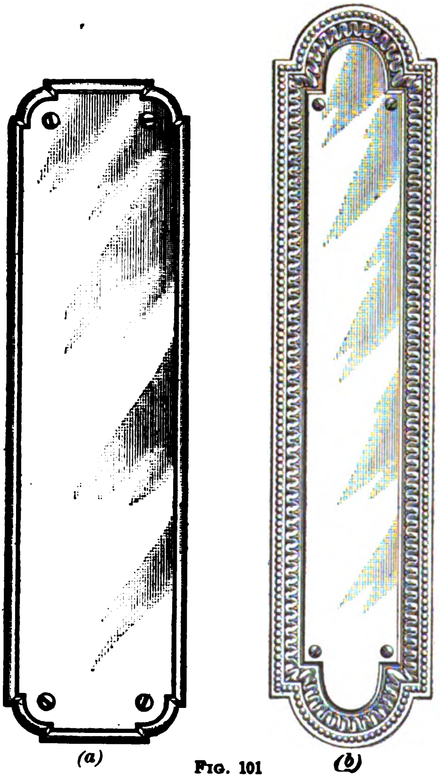


Fig. 100

81. Push Plates. On double-acting or single-acting doors, such as storm and duplex doors, **push plates** are used to protect the woodwork against soiling and wear from handling. These plates are made in various


(a) Fig. 101 (b)

sizes, and are either plain or ornamented to harmonize with the other hardware. To obtain good results, push plates should be as wide as the lock stile, where possible, and from 12 to 30 inches long, according to conditions and use. Plates 20 inches or less in length should be placed on the door so that the distance from the floor to the center of the plate is about 4 feet 6 inches; for larger plates the distance from the floor to the top of the plate should be 5 feet. If used in connection with a cylinder dead lock, the plate should be cut or drilled, preferably near the bottom, to allow the cylinder of the lock to pass through the plate. The plain type of push plate is illustrated in Fig. 101 (*a*), while one of more ornamental design is shown at (*b*).

82. Sign Plates.—Although metallic plates with lettering are not usually included in the hardware specifications, they find extensive use in hotels, banks, and other public buildings. The inscriptions available cover every possible demand, including titles of officers, names of rooms, etc.

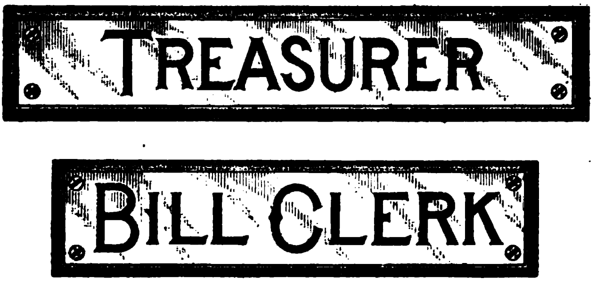


FIG. 102

Sign plates of various sizes can be procured in the following finishes: Bronze, brass, or nickel with either sunken or raised black letters; bronze or brass with black background or matte; white porcelain plate with blue, red, or gilt letters; and blue porcelain with white letters. Two typical sign plates are shown in Fig. 102.

83. Door Stops and Holders.—Since door checks and double-acting doors have come into more extensive use, the necessity of holding doors open has created a demand for *door stops* and *holders*. The **door stop** is a device for limiting the backward swing of a door. This device may also be constructed so as to perform the additional function of holding the door in an open position; it is then known as a **door holder.**

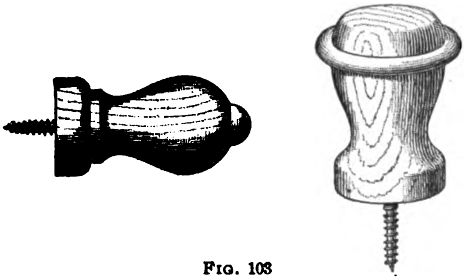


FIG. 103

The ordinary door stop is simply a wooden knob with rubber tip or ring that may be fastened to the floor or a baseboard, and is usually made up in the forms shown in Fig. 103. Better grades made of iron or bronze are also available. These come in various shapes, as shown in Fig. 104. Frequently, as shown at (*a*), a hook for fastening the door in an open position is combined with the door stop.

The door stop with the hook holdback is not always convenient to use, so that the *automatic holdback*, or *door holder*, shown in Fig. 105 is sometimes employed. This holder can be disengaged by a pull on the handle of the

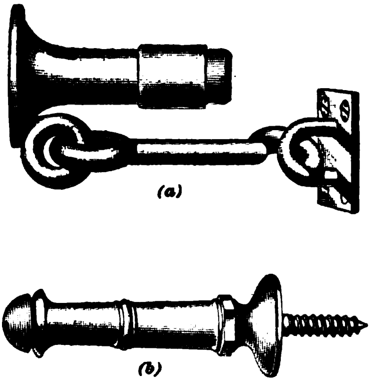


FIG. 104

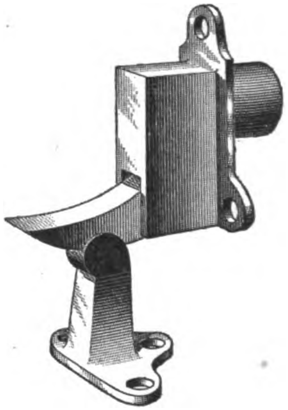


FIG. 105

door and automatically catches the door in an entire open position.

Where it is desired to hold a door in any position or to release it quickly, the rubber-tipped holder shown in Fig. 106 should be used; this device is easily operated and controlled by the foot.

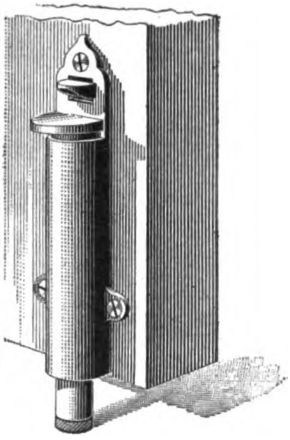


FIG. 106

84. Chain Door Fastener. The type of **chain fastener** illustrated in Fig. 107 is generally used on exterior residence doors. This device allows the occupants to open the door partly without permitting entrance. It consists of a heavy chain, one end of which is attached to a plate, which in turn is fastened to the jamb with screws. The other end of the chain carries a ball or a hook that may be inserted in the slot of the long plate, which is attached to the door. By this means, the door may be opened only slightly, until the ball of the chain is released from the slot.

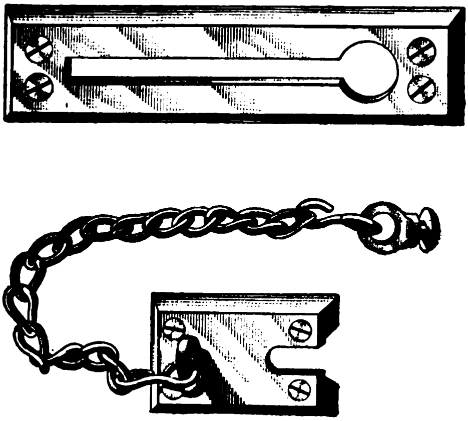


FIG. 107

85. Door Bolts.—A large variety of **door bolts** is now on the market. These bolts are made in all sizes, in wrought steel, cast iron, brass, and bronze, and may be procured in any finish desired. The several types of bolts used in common practice are illustrated in Figs. 108 and 109. In Fig. 108 (*a*) is shown a type of *barrel bolt;* at (*b*) is shown what is known as a *cased bolt;* and at (*c*) is shown a *necked bolt.* Fig. 109 (*a*) shows a *spring bolt*, (*b*) a *spring-necked bolt*, and (*c*) a type of *shutter bolt*. Various types of *mortise bolts* are illustrated in Fig. 110.

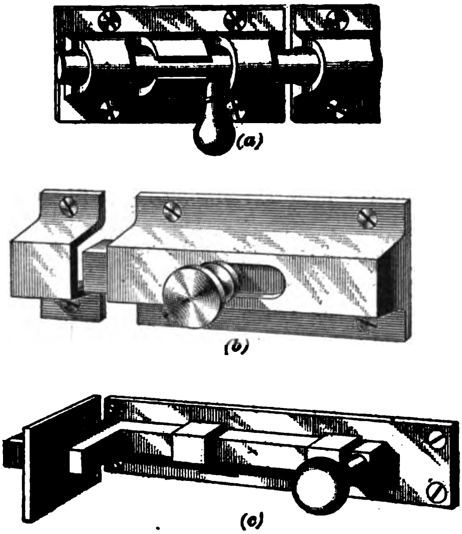


FIG. 108

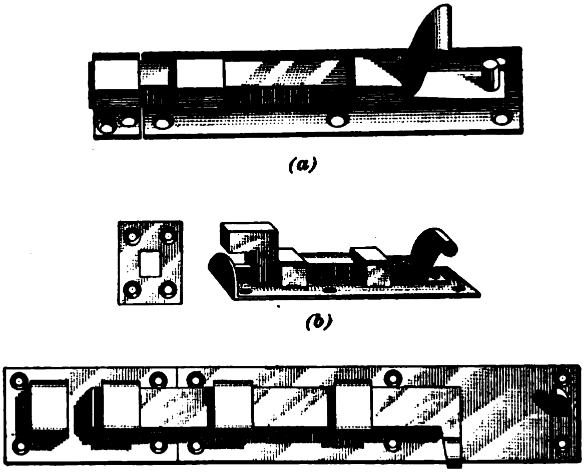


FIG. 109.

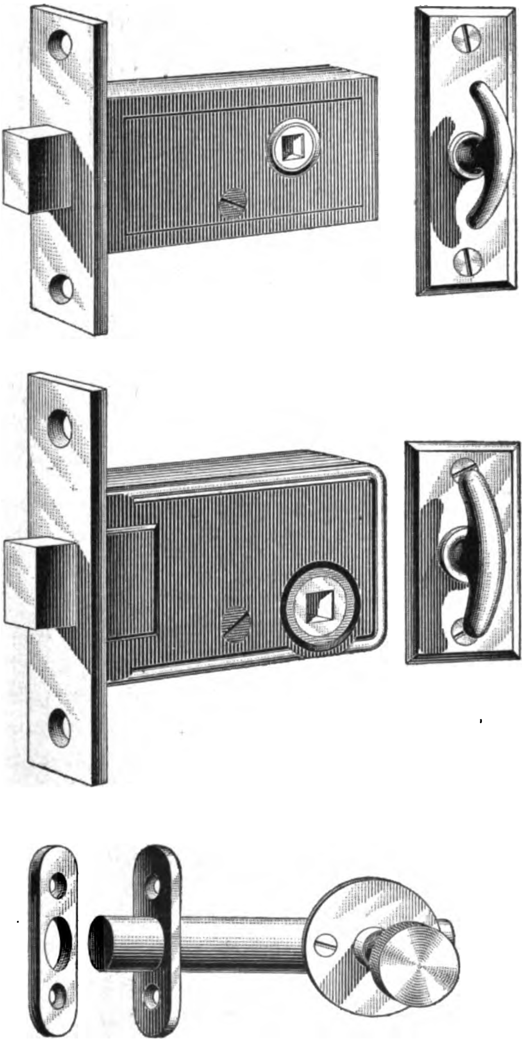
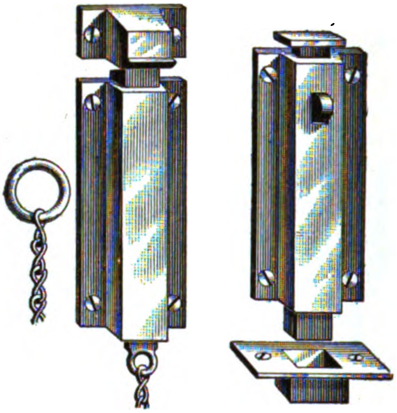


FIG. 110

86. Chain Bolts and Foot-Bolts.—A type of rim bolt used chiefly to secure the standing leaf of double doors is



(a) (b)

FIG. 111

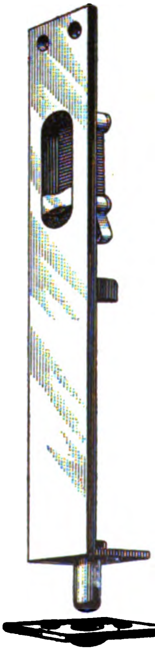


FIG. 112

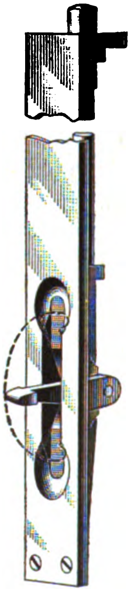


FIG. 113

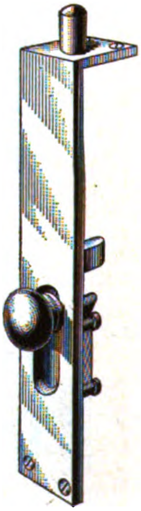


FIG. 114

shown in Fig. 111. These bolts are made in various sizes, finishes, and grades, and in both plain and ornamental design. In the figure, the **chain bolt** is shown at (*a*), while the **foot-bolt** is illustrated at (*b*).

87. Flush Bolts.—Bolts that are intended to perform the same function as chain bolts and foot-bolts, but are sunk into the stile of the door flush with its surface or edge, are known as **flush bolts.** These bolts, which are illustrated in Figs. 112 and 113, are made in various styles, grades, and finishes, from the smaller kinds for cabinet purposes to the large, double-mortise extension bolt. A flush bolt with a knob is shown in Fig. 114, while a *heavy, T-handle extension bolt* is shown in Fig. 115.

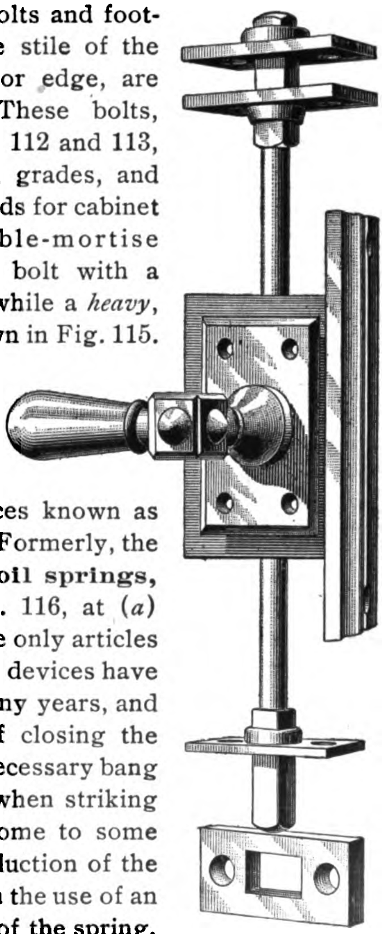


FIG. 115

88. Door Springs and Checks.—During recent years considerable improvement has been noticeable in the construction of the devices known as **door springs and checks.** Formerly, the common **torsion rod** and **coil springs,** which are illustrated in Fig. 116, at (*a*) and (*b*), respectively, were the only articles of this kind available. These devices have been in extensive use for many years, and have performed the work of closing the door, but not without the unnecessary bang and slam made by the door when striking the jambs. This was overcome to some extent, however, by the introduction of the **air-check,** which depends on the use of an air cushion to resist the force of the spring. In effect, each check is a small air pump.

Prominent among the older type of air-checks is the *Eclipse* made by Sargent & Co. This check is clearly illustrated in Fig. 117. At (*a*) and (*b*) are shown two methods of applying the *Eclipse* air-checks. In (*a*), the spring-check that closes the door is shown at *a* attached to the door, while its lever-arm is fastened to the door casing. The cylinder *b* is also secured to the door, and the piston *c*, operating in the cylinder, is applied to the door casing. At (*b*), the parts are differently arranged. The spring-check occupies the same relative position as shown in (*a*), its lever-arm being shown at *a*, while the piston *c* is fastened to the door and the cylinder *b* affixed to the head-jamb of the door frame. Either method is adapted for inside doors, but that shown at (*b*) is preferable for doors opening outwards, on account of fewer parts being exposed; the spring-check and its lever-arms, in this case, being the only parts exposed to the weather. In construction these checks consist of a cylinder *b* with a polished interior, in which works the piston *c*. On the end of the piston there is provided a cup made of leather that has previously been soaked in oil. By the insertion of the piston into the cylinder as the door closes, there is a tendency to compress the air in the cylinder, thus forming an air cushion with air outlet at the caps. These outlets can be regulated by turning, or screwing, the cap to the right or the left, as the case may require.

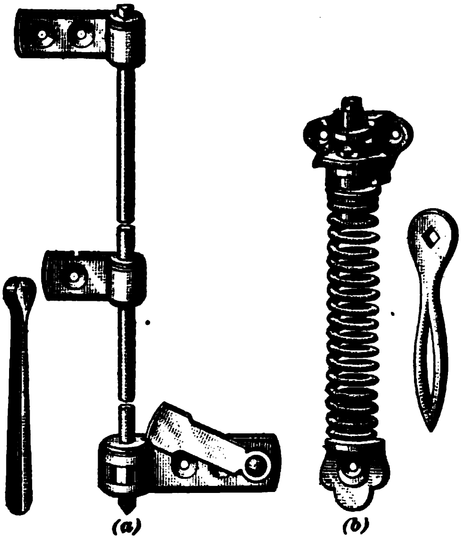
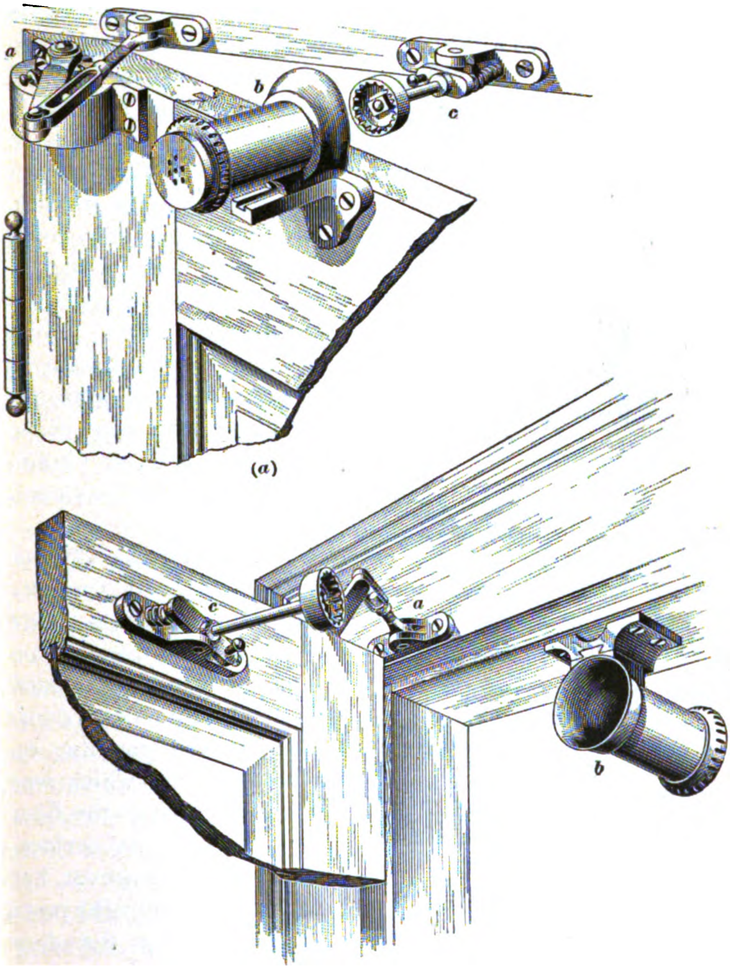

(a) (b)

FIG. 116

Devices of this kind, however, did not prove satisfactory until the introduction of the *Yale-Blount*, or *hydraulic*, *combined* *spring and check*, which is shown in Fig. 118. In this device, the coil spring *a*, shown in (*b*), is enclosed in the vertical portion of the check, the regulating of the tension being accomplished by turning the ratchet sleeve *b* with a wrench made for that purpose. The check enclosed in the horizontal part consists of a metallic piston *c*, without packing, that

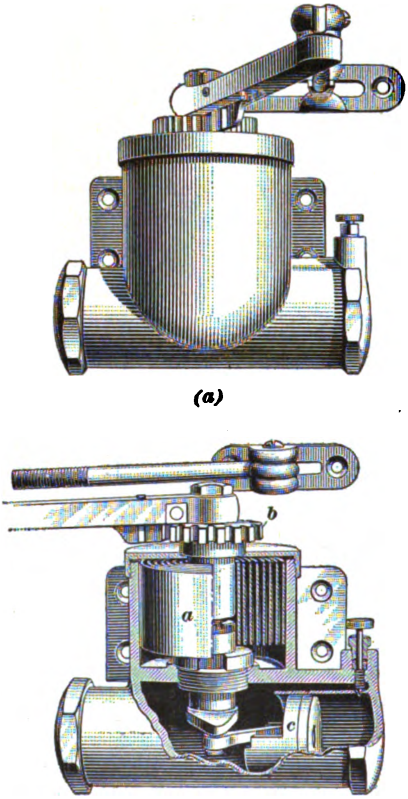


(*a*)

(*b*)

FIG. 117

moves in a tightly sealed metallic cylinder containing a lubricating and non-freezing liquid. The movement of the door in closing depends on the escape of the liquid through a by-pass from one end of the cylinder to the center, this by-pass being controlled by a small valve that may be readily adjusted to produce any desired action of the door and thus permit the door to be closed silently, with a smooth, steady motion, and without rebound. Since the introduction of the Yale-Blount type of check and spring combined, other manufacturers are making similar styles, the most prominent being the *Bardsley*, the *Corbin*, the *Sargent*, and the *Ogden*.



(a)

(b)

Fig. 118

89. Sliding-Door Hangers and Track. The first sliding doors were usually carried on sheaves, or rollers, located at the bottom of a door, these rollers traveling on a metal track, which was either inserted in the floor or placed on its surface. This system, however, has been displaced by the more modern **sliding-door hanger,** which suspends the door from the top. The carriers containing the rollers, or wheels, run on an overhead track placed in a recess formed for that purpose above the soffit of the doorway.

The use of the overhead hanger requires a special construction of the head-jamb, not only to provide space for the overhead track, but also to furnish proper support for the brackets securing the same. It is therefore a good plan to determine in advance the type of hanger to be used, in order that the framing and other details of the doorway may be made to conform to it. The most important features to be considered in the selection of sliding-door hangers are the strength and stiffness of track, the provision for adjusting and reducing friction and noise, the strength and quality of the several parts, and the facility with which these parts can be fitted in place and adjusted when in use.

In order to overcome noise, the original overhead hanger was made with wooden track, which was placed on each side of the recess. On this track rolled the wheels in pairs, being generally riveted to an axle and having a space between them. The frame of the hanger traveled on the axle from end to end, to overcome friction, the adjustment being only in the hanger frame. Of this type of door hanger, the *Prindle*, the *Stearns*, the *Warner*, the *Ives*, and the *Richards* were the most widely used. The Ives improved wooden-track, house-door hanger is illustrated in Fig. 119.

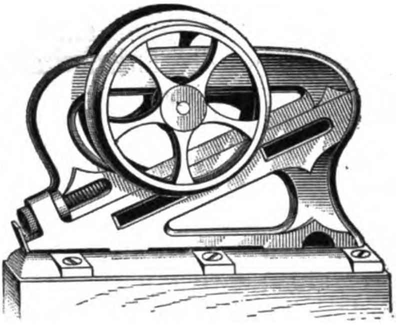


FIG. 119

Another form of sliding-door hanger, which is considered an improvement over the type just described, consists of the single or side steel-track hanger of the Lane or the Richards make. These sliding-door hangers are constructed entirely of steel, and the hanger proper has frictionless bearings, on the principle of the wooden-track hangers, but with one wheel to each hanger, running on a steel track fastened to one side of the recess. This combination is quite an improvement over the old-style hanger, and can be placed in position more readily. The wheels of these hangers, as shown in Fig. 120, are constructed of two plates of steel, between which is placed a fiber wheel that is held in position by through rivets. The fiber portion of the wheel comes in contact with the track, while the plates act only as flanges, thus tending to reduce the noise caused by the operation of the door.

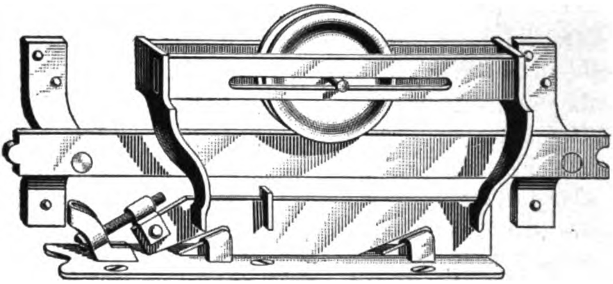


Fig. 120

The hangers most extensively used at present are the **trolley type,** of which the *Coburn* is the original and the best of the various kinds. The track, a typical section of which is shown in Fig. 121, is made of sheet steel, which is bent or folded into various forms, depending on the particular make. The carrier is contained in the interior of the track. The several features of this type of track and hanger are illustrated in Figs. 122, 123, and 124, which likewise show the method of attachment and the detail construction of the door head, or soffit, necessary to receive these tracks and hangers.

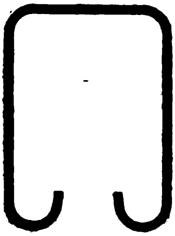


Fig. 121

This type of sliding-door trolley track is also sometimes lined with wood placed in the steel trough, or track, as shown in Fig. 125. This makes the device absolutely noiseless, although the regular types operate with very little noise. Besides the Coburn trolley and track, there are the *Richard* and the *McCabe.* Both of these makes possess merit. The trolleys, or carriers, are constructed with both fiber and iron wheels, with ball bearings, running on a wooden or metal track, according to the type.

This type of hanger and track is made in all sizes, from the smallest, for hanging small bookcase doors, up to the

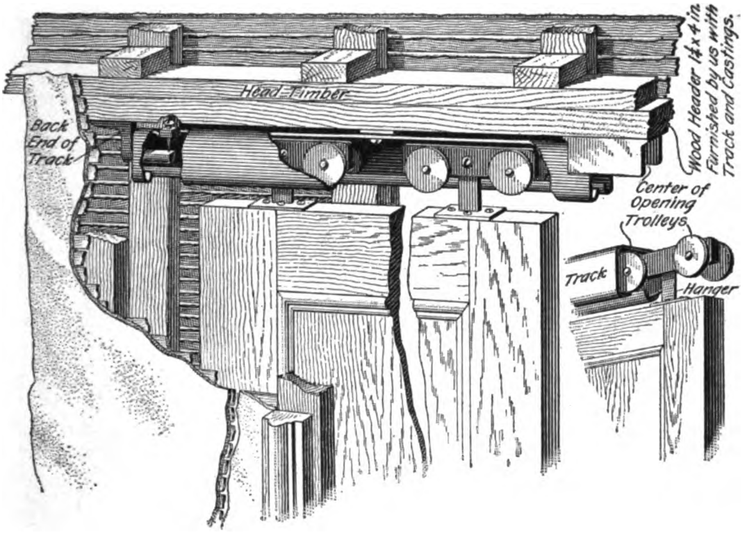

Head Timber
Back End of Track
Wood Header 1¾ x 4 in. Furnished by us with Track and Castings.
Center of Opening Trolleys
Track
Hanger

FIG. 122

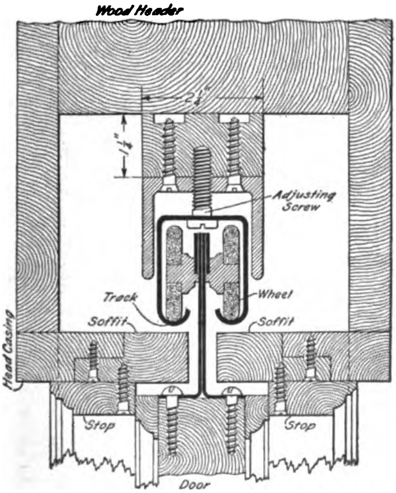


FIG. 123

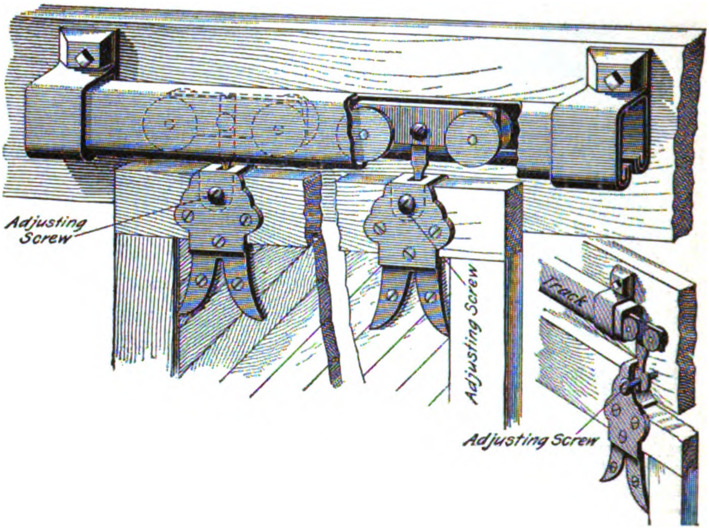


FIG. 124

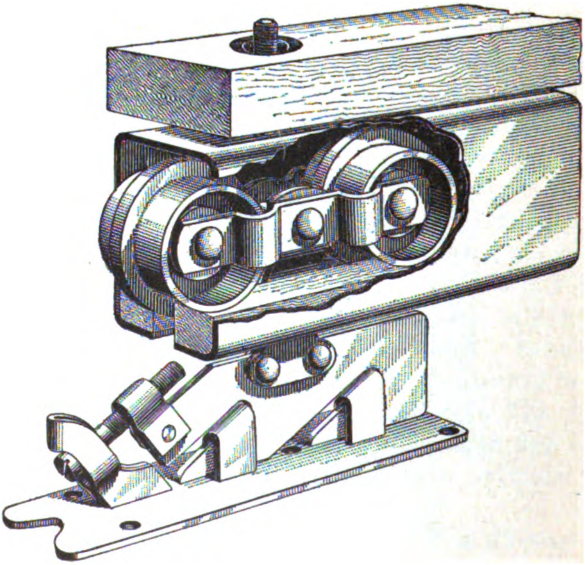


FIG. 125

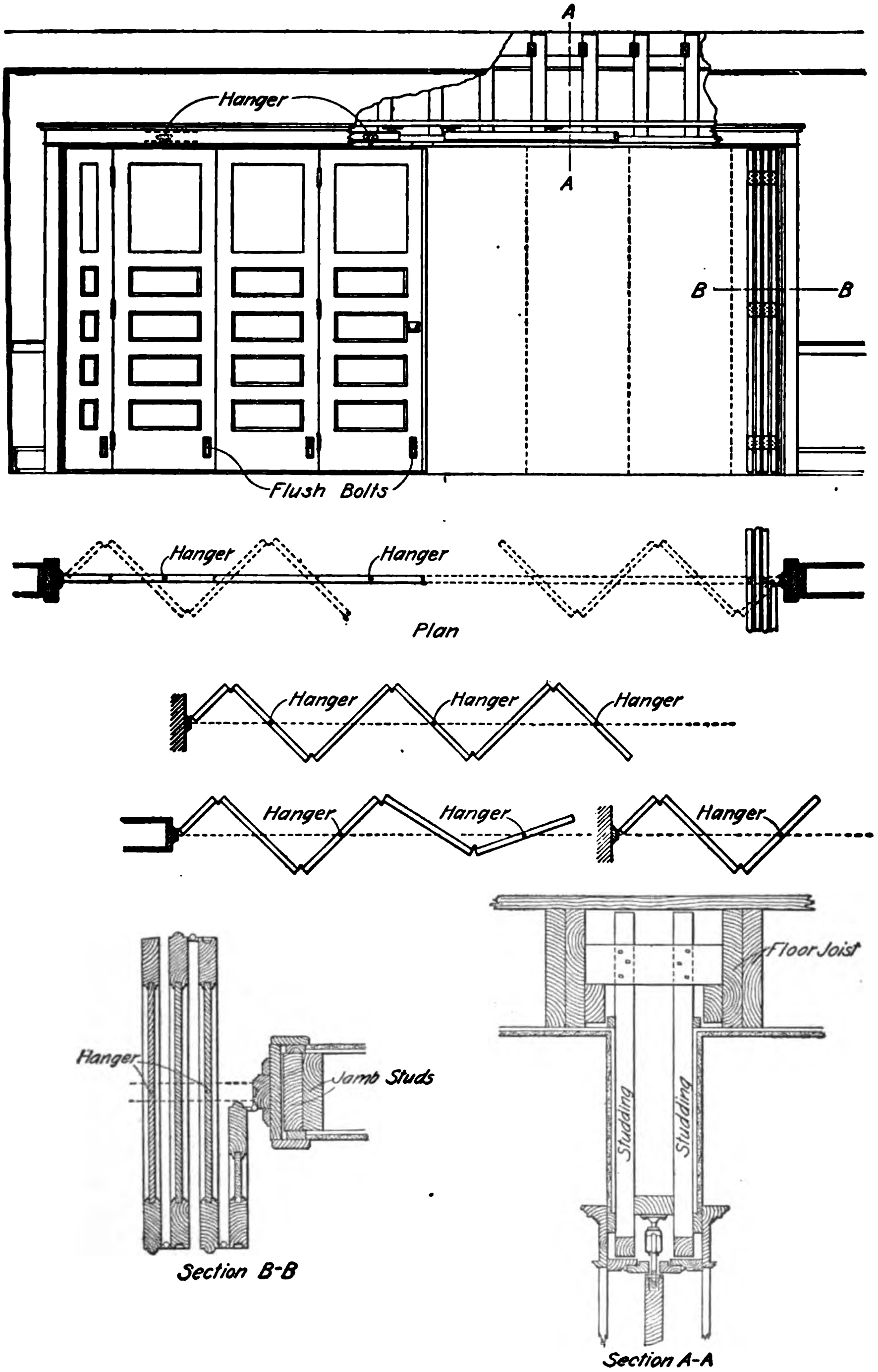

A
Hanger
A
B
B
Flush Bolts
Hanger
Hanger
Plan
Hanger
Hanger
Hanger
Hanger
Hanger
Hanger
Floor Joist
Hanger
Jamb Studs
Studding
Studding
Section B-B
Section A-A

Fig. 126

very largest, for warehouse doors. As shown in Fig. 126, trolley hangers are made for doors of special design, such as accordeon and parallel doors used to close up large openings. They are also made for elevator doors, freight-car doors, barn doors, and automatic fire-doors, with special construction to suit the various purposes.

In factory and similar buildings, it frequently happens that one portion must be separated from another by brick fire-walls, and that the openings in these walls have to be closed with tin-covered doors as required by the National Board of Fire Underwriters, the object being to reduce the fire hazard. Wherever possible, these doors are made sliding and arranged so as to close automatically, being hung on a slanting track with an incline of ¾ inch to the foot, and also counterbalanced with weights so that the door will stand at any point, as shown in Fig. 127. The cord or rope attached

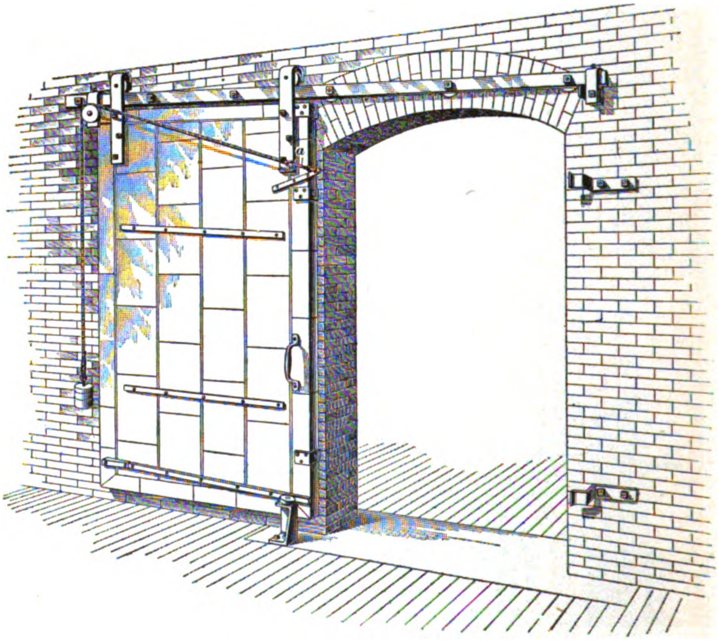


Fig. 127

to the weights passes over a pulley and is attached to the door with a fusible link, as at *a*, which, in case of fire, gives way and allows the door to close automatically.

The doors are usually constructed of seasoned white pine or similar non-resinous wood, using three thicknesses of ⅞-inch matched boards, the outside layers to be vertical and inner layers horizontal and thoroughly fastened together with wrought-iron clinch nails, driven in flush and well clinched. The doors are then covered with 14″ × 20″ IC bright charcoal tin plates of not less than 107 pounds to a box of 112 sheets. All joints are locked ½ inch, without soldering, and nailed under the seams.

The track for these doors is best made of round-edge bar iron or tire steel, ⅜ in. × 3½ in., being bolted to the wall with through bolts having nut and flanged washer on the opposite side, and held from the wall by cast-iron track brackets. The hangers are of wrought iron, ⅜ in. × 3½ in., provided with roller-bearing wheels and are attached to the door with at least two bolts. The binders are of wrought metal, ⅜ in. × 3½ in., with angle flange at back end to notch in the wall and so arranged as to grip and force the door against the wall when closed. In connection with this, a wedge is placed at the end of the lower chafing strip, and, when the door is closed, engages with the stay-roll so that the door will be held close to the wall on the opposite side. Two chafing strips of ¾-inch, half-oval metal are placed on back of door with 1″ × ⅛″ flat strips of same length in front and bolted through the door. Bumper shoes are also used to prevent the binders from mutilating or damaging the tin covering at the points that strike the binders.

90. Door Knockers.—Although the medieval **door knockers** have been replaced by the modern door and electric bell, they are still used occasionally for decorative purposes, and, when required, they should be selected and specified with the finishing hardware. Door knockers are made in various styles, sizes, and finishes—in iron, brass, or bronze—to match the several designs expressed in hardware. The

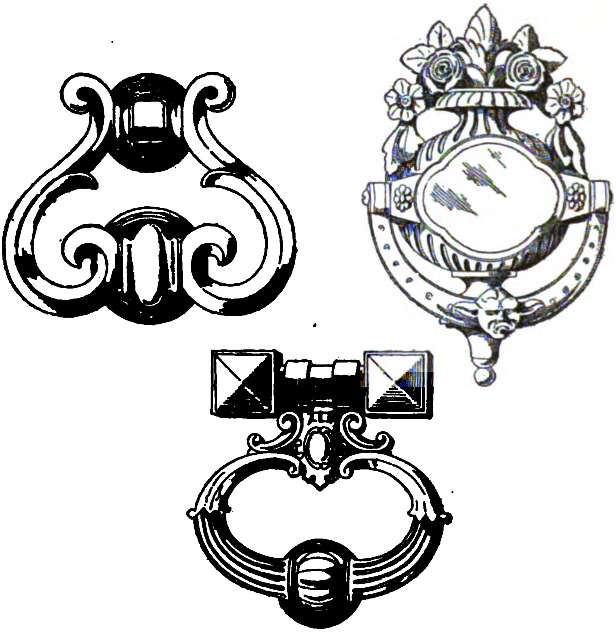


FIG. 128

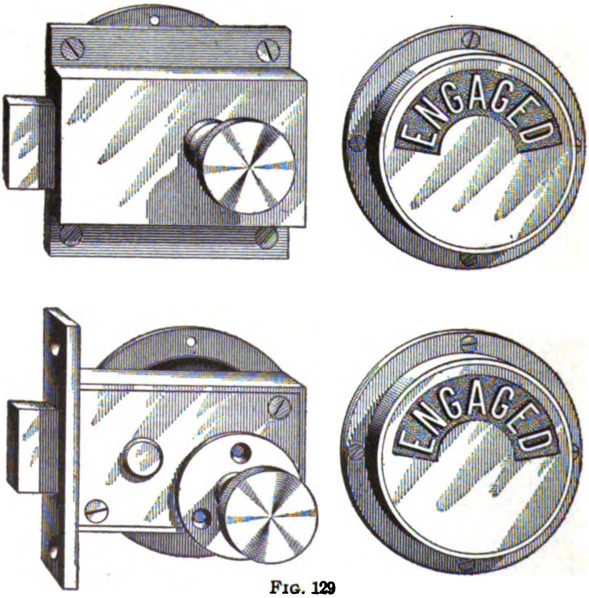


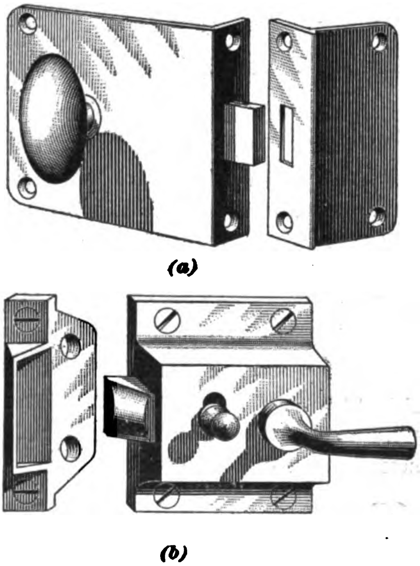
FIG. 129

elaborateness of the designs of this somewhat ornamental piece of hardware is shown in Fig. 128.

91. Water-Closet Door Trim.—The construction of water closets in public buildings has brought forth special hardware to meet the various conditions of convenience, simplicity, and hard usage. In ordinary work, the doors of water-closet compartments are secured with a hook or a barrel bolt, while in the better class of work, as in hotels and public places of this character, mortised thumb or knob bolts or, better, indicator bolts are used.

Indicator bolts, as shown in Fig. 129, made both mortise and rim, are available for water-closet doors. In either case, the bolts are mortised into or placed on the inside of the door with the indicator case on the outside. The indicator dial has a spindle on the back, and this engages with the knob that operates the bolt. When the bolt is thrown, the indicator shows the word "Engaged," and when turned back, the word "Open" appears.

A simple form of fastening for water-closet doors is shown in Fig. 130, which illustrates the flush, or half-mortise, knob bolt at (*a*), and the water-closet rim latch at (*b*). The rim slide bolt is also used for securing water-closet doors. All of these bolts are available for wooden partitions, and may be had for marble or slate work, when special strikes and bolts for fastening will be required.


(*a*)

(*b*)

FIG. 130

Jamb door stops are seldom required for water-closet doors hung to wooden partitions, but when needed there is to be had a simple stop with a rubber tip that will answer all purposes. Where stops are required for doors hung to marble partitions the type shown in Fig. 131 may be used. This stop has a clamp device that is attached to the marble slab by bolts and it will be observed forms a combination stop and strike for the latch or bolt.

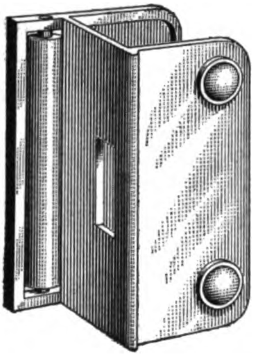


FIG. 131

Other water-closet specialties, which are not illustrated here but which are sometimes specified under hardware, are: Coat-and-hat hooks, cigar holders, cigar and paper holders combined, and toilet-paper holders. Each can be procured to secure to either wood or marble, as required.

92. Screen-Door Latches.—There is a light latch manufactured, either rim or mortise, for use on screen doors. It consists of a knob latch similar to a mortise latch or cupboard turn, but in addition to a hub, as in the former, it is furnished with a spindle and a pair of knobs, or lever handles. Latches for screen doors are also constructed with "stop-work," so that they cannot be operated from the outside except by the means of a key. This latter latch is generally of the mortise type, having escutcheons on both sides.

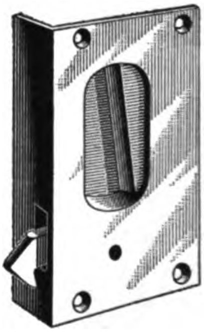


FIG. 132

93. Elevator Latches.—Locks or latches for use on doors of elevator shafts are usually operated by a key from the outside and by a flush lever handle from the inside. The latch illustrated in Fig. 132 consists of a pivoted arm with a hook at its end to engage with a strike on the jamb. This type of latch is the one generally employed.

94. Secret Gate Latch.—In Fig. 133 is shown a **secret gate latch,** which is used for office gates. Latches of this kind may be had in either the rim or the mortise type. They usually consist of a spring bolt that cannot be operated except by a concealed button or similar device. In the type of latch shown in the figure, the concealed button that controls the latch is located on the lower edge. The knob shown is fixed and does not operate the latch.

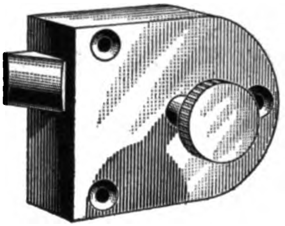


FIG. 133

95. Ornamental Nails and Studs.—Although the constructive necessity for **ornamental studs** and **nail heads** has disappeared under modern methods of wooden construction, they are still used for purposes of decoration, and a great variety may be had. Several stock designs are illustrated in Fig. 134. These nails and studs are made of various metals and in many finishes, having a projecting spur on the back that, when driven into the wood, firmly attaches the ornamental head in place. They contribute effectively to the decoration of important doors, especially extension doors of churches and public buildings.

96. Hand and Bevel of Doors.—Many locks and butts used at the present time are made *reversible;* that is, they can be used for either right- or left-hand doors. Others are not, and must therefore be specified as *right hand* or *left hand.* In this latter class are included loose-joint butts and most locks, the operation of which is different on one side than on the other. All locks with beveled fronts are not reversible, and their use should be avoided where no real need of them exists.

A **reversible lock** is one having a beveled latch bolt that can be turned over, or reversed, at will, to make its bevel face the opposite direction. This is usually accomplished by removing the cap of the lock and turning over the latch bolt.

In order that hardware may be ordered intelligently, the *hand* and *bevel* of the door should be given where the hardware is not interchangeable, or reversible. Rules to determine the hand of doors have, therefore, been

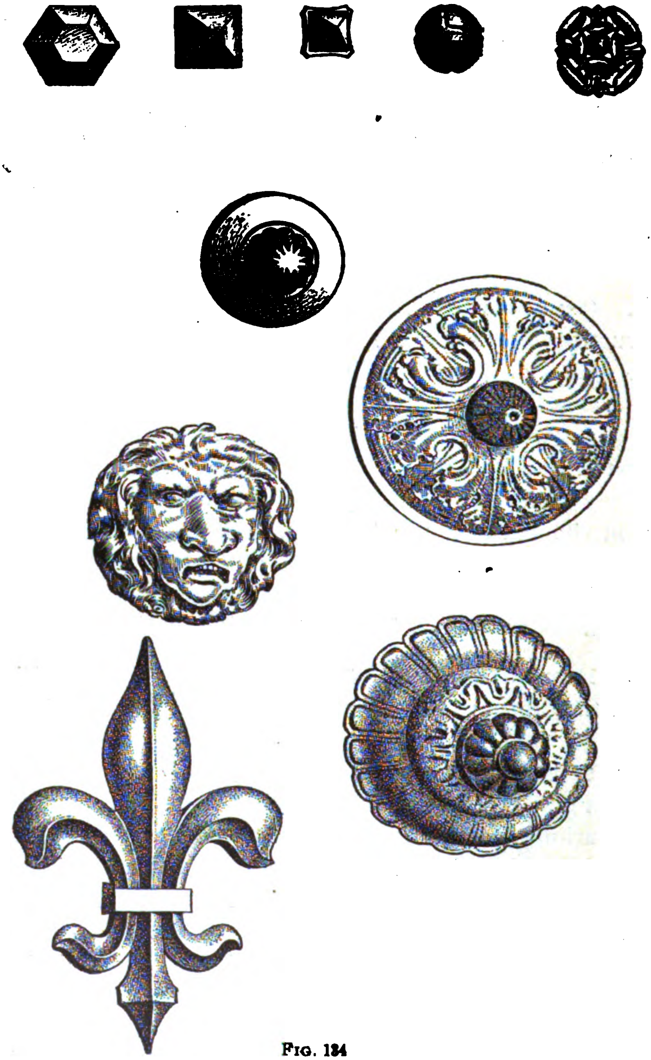


FIG. 184

established by the manufacturers of hardware, so that the information may be founded on a uniform basis. Reference to Fig. 135 will materially assist in the interpretation of these rules.

1. The **hand** of a door is always determined from the outside.

2. The **outside** is the street side of an entrance door, the corridor side of a room door, and the room side of a closet door. The outside of a communicating door, from room to room, is the side from which, when the door is closed, the butts are not visible. The outside of a pair of twin doors

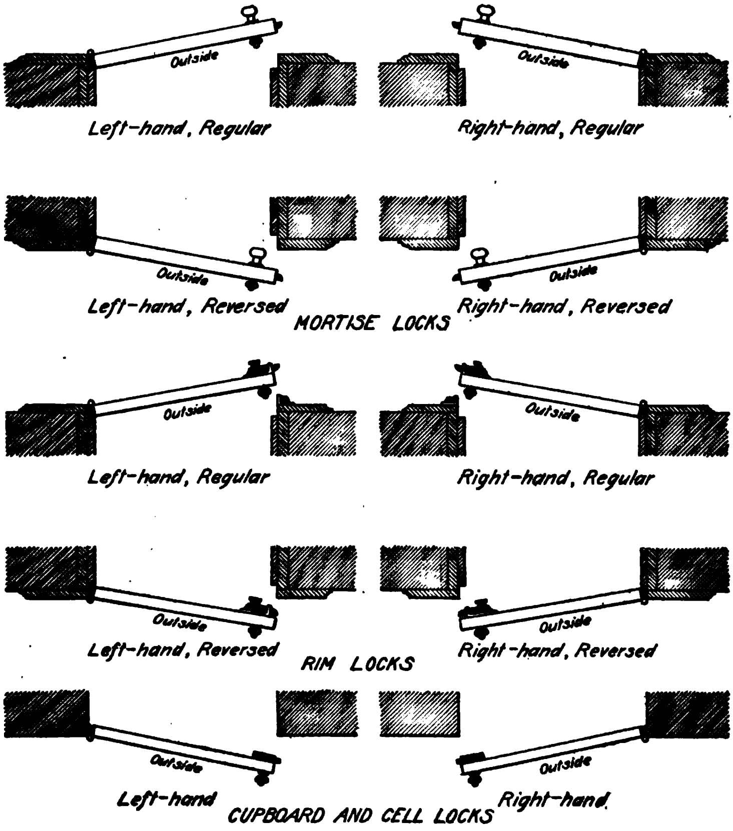


Fig. 135

is the space between them. This rule applies to sliding doors as well as hinged doors.

3. If, on standing outside of a door, the butts are on the right, it is a *right-hand door;* if on the left, it is a *left-hand door.*

4. If, on standing outside, the door opens from you, or inwards, it takes a lock with *regular* bevel bolt; if it opens outwards, it takes a lock with *reverse* bevel bolt.

5. A door is beveled when its edge is not at a right angle with its surface, and in this case the front of a mortise lock must be beveled to correspond. This bevel is expressed by stating the thickness of door and the distance that one edge drops back of the other. The standard bevel is ⅛ inch in 2¼ inches, as shown in Fig. 136.

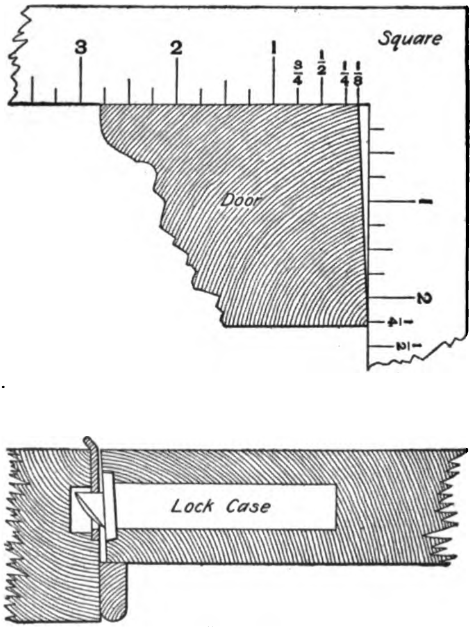


FIG. 136

6. The bevel of a lock is a term used both with mortise and rim locks to indicate the direction in which the bevel of the latch bolt is inclined. If inclined outwards, as for doors opening inwards, it is a *regular bevel bolt;* if inclined inwards, as for doors opening outwards, it is a *reverse bevel bolt* (except as to cabinet locks, which, being commonly used on doors opening outwards, are regularly made with reverse bevel bolts, unless otherwise specified).

Mortise locks used with double doors having either rabbeted or astragal joints, must have fronts of corresponding sectional form. To avoid the extra cost of special patterns, the edges, or joints, of such doors should conform to established lock standards. The standard rabbet, or step, in the edge of doors is ½ inch, and the standard astragal joint has a ¾-inch bead.

The proper bevel of a door, if any is needed, is determined by the size of butt and the width of the door, as shown in Fig. 137. The inner corner of the door travels on a radius with the center at the center of the pin of the butt, and must have a clearance to swing free of the jamb casing. This may be obtained by beveling the edge of the door, or, if its edge is left square, by leaving sufficient clearance between the door and its jamb. If the door is of fair width and the butt does not need to be very wide to clear the trim, it will be found that a square edge may be used without resorting to an unduly open joint, thus permitting the use of locks with regular front; that is, not beveled.

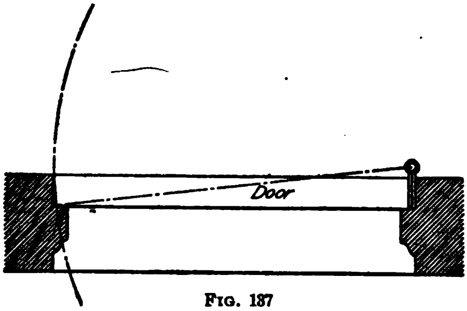


Fig. 137

SHUTTER HARDWARE

97. Shutter Fasteners, or Adjusters.—The most convenient fastener for shutters, or blinds, is the *Zimmerman*, or *Walling*, *type*, as shown in Fig. 138. These fasteners or adjusters secure the shutter in the closed, the open, and several intermediate positions, and are made both japanned and galvanized. They can be used with all styles of hinges, although they are generally combined with regular butts or with the New York blind hinge.

98. Shutter Rings.—In Fig. 139 is shown a **shutter ring.** Rings should always be used on solid shutters to close them; the shutter being solid, furnishes in itself no edge which can be clasped in closing, which is not the case with slatted blinds. These shutter rings are tinned or galvanized to prevent rusting, although they may also be obtained japanned. A better type of shutter ring is that having an eye riveted to a plate, which in turn is attached to the shutter with several screws.

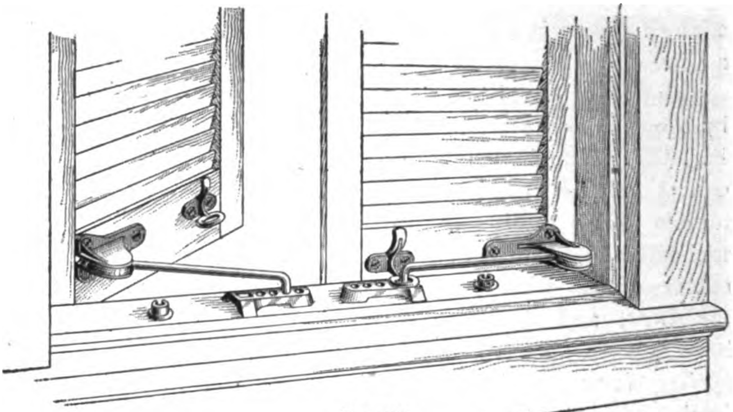


FIG. 138

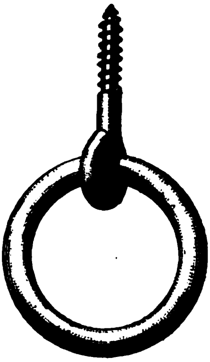


FIG. 139

99. Shutter Bolts.—Bolts are used for securing both slatted and solid shutters, but are chiefly intended for the solid shutter, which is used for protection. Shutter bolts are made of wrought steel in various sizes, from 6 to 16 inches long, and are to be had either japanned or galvanized. While the same shutter bolts are used on slatted blinds for keeping the blinds in a closed position, they afford little protection, as they can usually be operated through the slats. Common types of shutter bolts are illustrated in Fig. 140. At (*a*) is shown the ordinary wrought-steel shutter bolt, while the one shown at (*b*) is practically the same bolt with a lock attachment at *a*.

100. Shutter Workers.—The **shutter worker** known as the *Mallory* is an exceptionally good article for hanging shutters. The lower hinge is made in box form, enclosing the gear necessary to operate the blind; a square shaft connects this with a lever handle, or crank, fastened to the casing inside the building, thus allowing the user to operate the shutter from the inside without opening the sash or screen. The cog gearing in the lower hinge will hold the shutter in the closed, the open, or any desired intermediate position without the use of any other device.

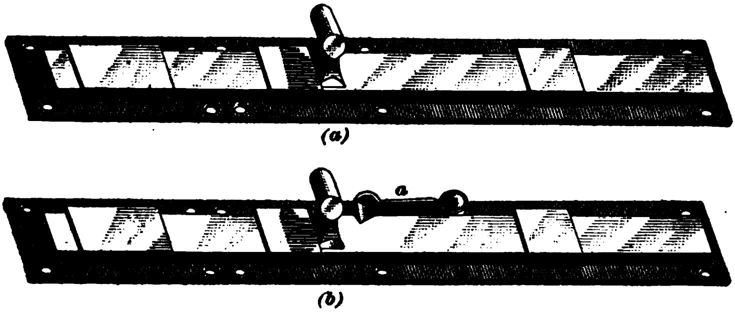


FIG. 140

101. Turnbuckles.—The device shown in Fig. 141 is known as a **turnbuckle**; it is employed for fastening shutters in an open position against a building. Turnbuckles are made of cast iron or of wrought steel, and for use on either frame or brick buildings. They may be used in connection with all styles of hinges, and are generally employed on buildings that are exposed to exceedingly strong winds.

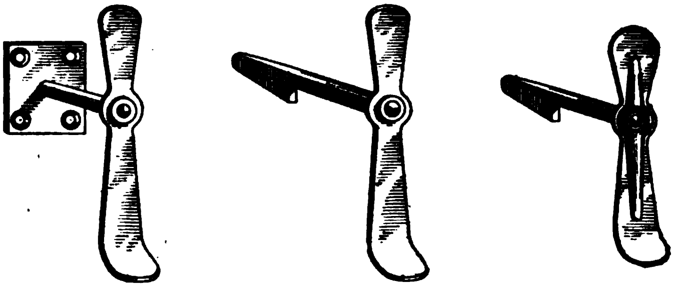


FIG. 141

CABINET TRIM

102. Hinge Butts and Hinges.—For cabinetwork, small, light hinge butts are used. These may be obtained in either bronze or steel, with or without ball tips, and in various sizes. The steel butts of this type are more commonly used, as they can be procured in all finishes, but for high-grade work, bronze metal is always employed. The usual type of cabinet hinge butt is illustrated in Fig. 142.

A surface hinge is sometimes used in place of a butt, in order to eliminate the fitting to the woodwork that is necessary where butts are used.

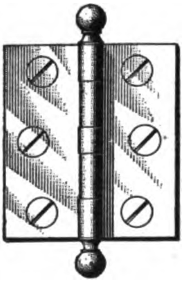


FIG. 142

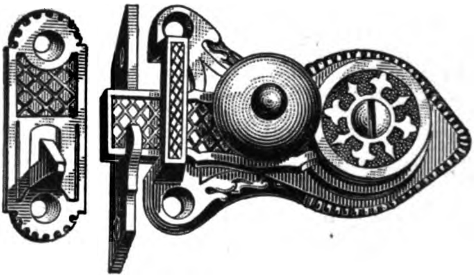


FIG. 143

103. Cupboard Latches.—A convenient fastening for cupboard doors, consisting of a pivoted latch actuated by a projecting knob, is shown in Fig. 143. This type of latch is furnished with two forms of strikes, one for application on the edge and the other for application on the surface of the jamb or door.

This figure shows a stock sample of this type of latch, but the student should carefully note that whenever possible such garish or gaudy ornament should always be avoided in all classes of hardware. Good taste is always better satisfied with simple and direct treatment as shown in Fig. 144; but where ornate styles are adopted, the character of the ornament should be artistically expressed as exemplified in Figs. 128, 134, 153, 155, 157, etc.

104. Cupboard Catches.—The **cupboard catch** differs from the cupboard latch just described, although it is intended for the same purpose. The usual cupboard catch consists of a spring bolt that is operated by a slide knob. It is made in various designs, sizes, and shapes, in both the rim and flush varieties. Figs. 144 and 145 show several types of cupboard catches.

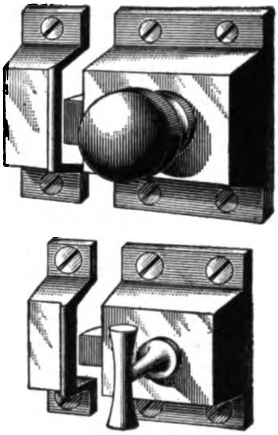


Fig. 144

105. Cupboard Turn.—There is a piece of hardware intended for the same purpose as the cupboard catch, known as the **cupboard turn.** It is operated by a rotating knob instead of the slide, and is considered the best rim article used for this purpose.

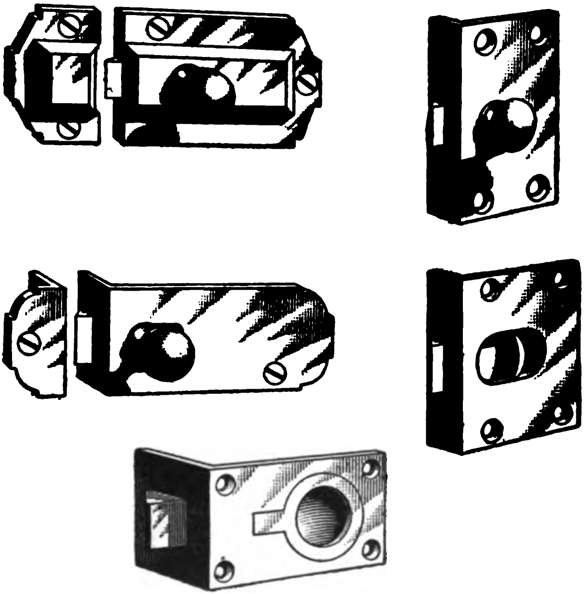


Fig. 145

106. Cupboard Buttons.—The **cupboard button** is an old device, but is little used at the present time, except for the cheapest work. Various types of these buttons are illustrated in Fig. 146. They are made with or without plates, as shown, and may be had in either iron or brass.

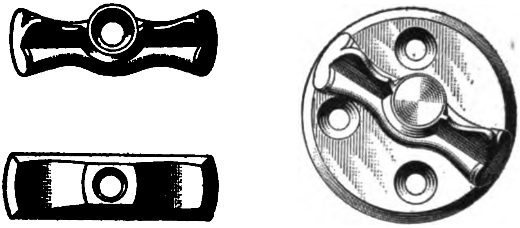
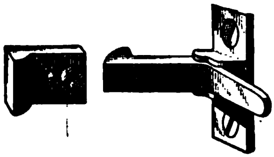


FIG. 146

107. Elbow Catches.—A convenient fastening that is in quite general use for the standing leaf of double doors is illustrated in Fig. 147, from which the operation may readily be understood. This device, which is commonly known as an **elbow catch**, fastens the doors automatically; it is easily operated in opening the doors, and thus does away with the old-style hook and eye. The strike of the catch should be placed beneath the shelf where possible, using the catch inverted.



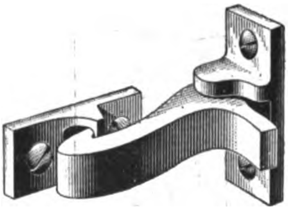


FIG. 147

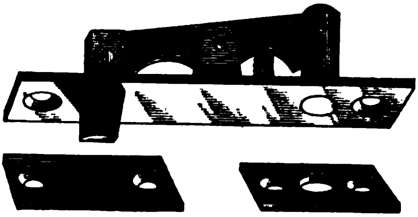


FIG. 148

108. Bookcase Bolt.—The **bookcase bolt,** shown in Fig. 148, is an automatic fastening device that is mortised into the soffit of cabinets or bookcases having double doors. It is arranged in such a position as to engage with the top of one door, and is operated by the act of closing the other door, which carries the lock, so that both doors are fastened or released by a single action.

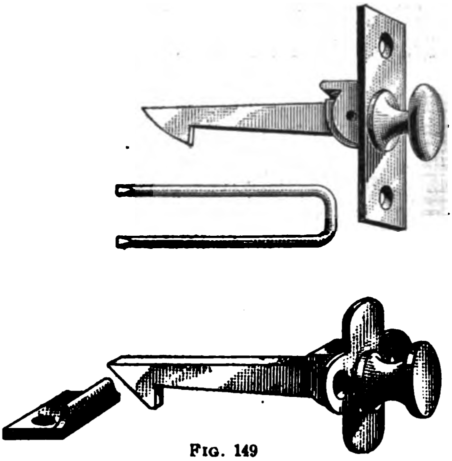


FIG. 149

109. Lever Cupboard Catches.—Another piece of hardware used for securing light doors, or leaves, such as are used in cupboards, bookcases, and wardrobes, is illustrated in Fig. 149. This fastening is very simple and convenient. It consists of a bar that is pivoted to a plate and extends through the door, its inner end being hooked to engage with a strike.

110. Drawer Pulls.—The **drawer pull** is a familiar article of cupboard hardware, the usual type being illustrated in Fig. 150. This article can be obtained in iron, steel, brass, or bronze, in various styles and shapes, and in all finishes. Drawer pulls with *label plates* are extensively used. A type of this drawer pull is shown in Fig. 151.

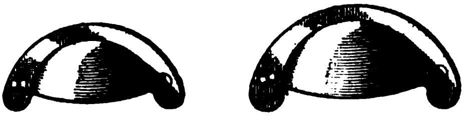


FIG. 150

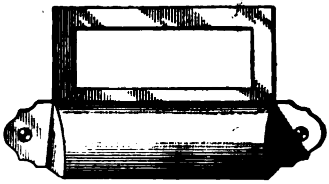
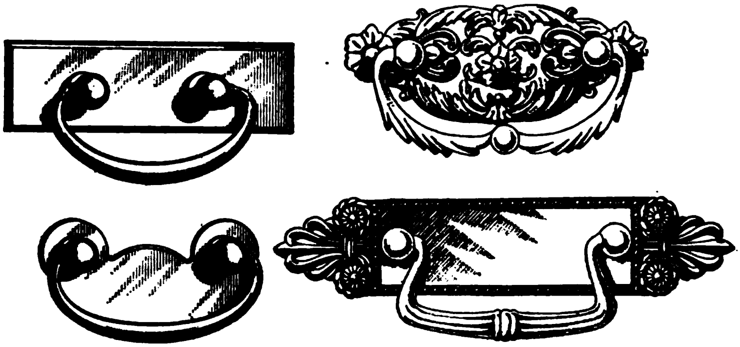


FIG. 151

111. Drop Drawer Pulls. For cabinetwork, the **drop drawer pull,** as illustrated in Fig. 152 (*a*), is used almost entirely. The drop pull is made both plain and ornamented, examples of each style being shown in Figs. 152 (*a*) and (*b*) and 153.

112. Cabinet Locks.—The type of lock illustrated in Fig. 154 is used on cabinetwork of every description, and can be procured for all classes of construction. These locks are made in rim, flush, and mortise styles, with keys having either plain or ornamental bows.



(*a*) (*b*)

Fig. 152

113. Cabinet Escutcheons.—In order to form a finish and protect the woodwork near the keyhole, the **cabinet escutcheon plate** is used. These plates are made in various sizes and styles of ornamentation, some designs of which are illustrated in Fig. 155.

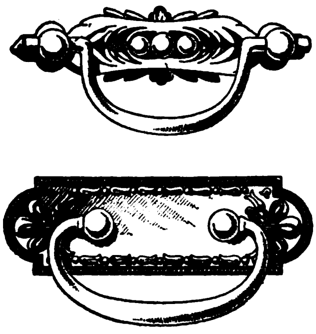


Fig. 153

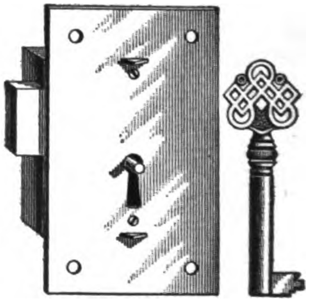


Fig. 154

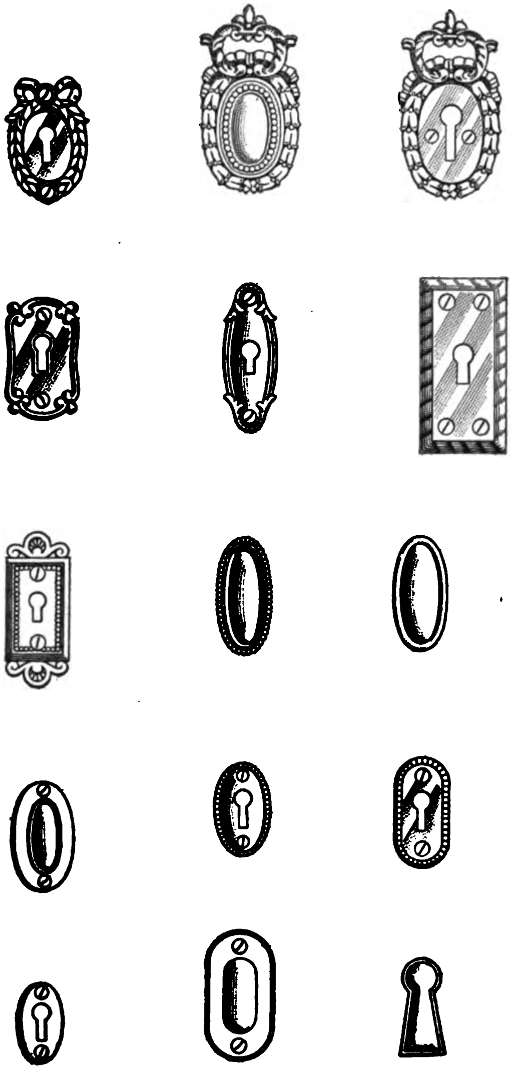


FIG. 155

114. Card Frames, or Label Plates.—An article known as the **card frame**, or **label plate**, is used extensively to placard drawers or cupboards to designate their contents. These plates are made in various sizes, and may be procured in bronze and iron and in the usual patterns shown in Fig. 156.

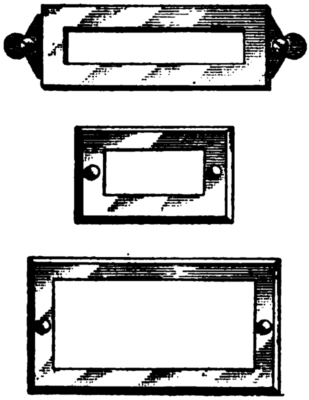


FIG. 156

115. Hinge and Corner Plates.—The **hinge** and **corner plate** is an article used solely for decorative purposes on cabinetwork. The variety of designs and sizes now available is such that special patterns are rarely necessary. These plates may be obtained from the hardware dealer in all of the usual metals and in all finishes.

DESIGN AND SPECIFICATION OF HARDWARE FOR BUILDINGS

HARDWARE OF SPECIAL DESIGN

116. Proprietary Hardware.—The manufacturers of hardware have assembled an extensive collection of standard designs in the various styles of ornament, from which fitting selections can be made for almost every use without danger of repetition and without fear that the design selected may become hackneyed by too general use. Therefore, before incurring the great expense entailed by the adoption of special designs, it is advisable that a careful examination of catalog designs be made. Where, however, it is decided to adopt some special design, the facilities of the manufacturer can be effectively utilized to secure the best results at the least cost and with the minimum amount of trouble to the architect or the owner.

Of all of the subordinate elements of interior decoration, there is none that offers a larger opportunity for effective results and for the exercise of personal taste than the metal work of the hardware for doors and windows, whether elaborate and costly, or simple and inexpensive. The knobs, plates, and hinges of a door compel attention by the prominence of their position. If they are inappropriate and unpleasing, they obtrude, while if artistic and in harmony with their surroundings, they attract and provide a finish unobtainable in other ways.

The impress of individuality marks all of the important work of the successful architect, and may be extended properly to the subordinate details of decoration, especially where it is essential that these harmonize with the general scheme. Hence, in some cases, the architect furnishes the designs for the hardware to correspond with the architectural treatment of the building. As, in the case of emblematic hardware, these individual designs involve the additional expense of special drawings, models, and patterns, the plan is seldom resorted to, except where the question of cost is subordinate to that of perfection of result.

117. For many years hardware has been generally regarded as an indifferent detail that could be safely left to the carpenter contractor to select and supply. Even when specified, it has been usually described in a very loose and vague manner, doubtless owing to the technical character of the information required and the difficulty entailed on a busy architect in obtaining and formulating it for use. Where, therefore, the conditions are such that an exact and carefully detailed hardware specification cannot be prepared, the only satisfactory plan is to exclude the finishing hardware from the specifications prepared for the building and reserve it for selection by the architect and the owner.

118. Emblematic Hardware.—Occasionally, it is found desirable to indicate the character or use of a building by introducing one or more appropriate emblems in the design or ornament of the hardware. This is especially true of structures for lodges, clubs, societies, and other organizations, in which case the emblems of regalia, badges, etc. are available for the motif of the design. In municipal, state, or government buildings, the coat of arms or public seal may be introduced in decorating the hardware, and in buildings for railroad companies, banks, etc., the monogram, seal, or name of the corporation is frequently reproduced.

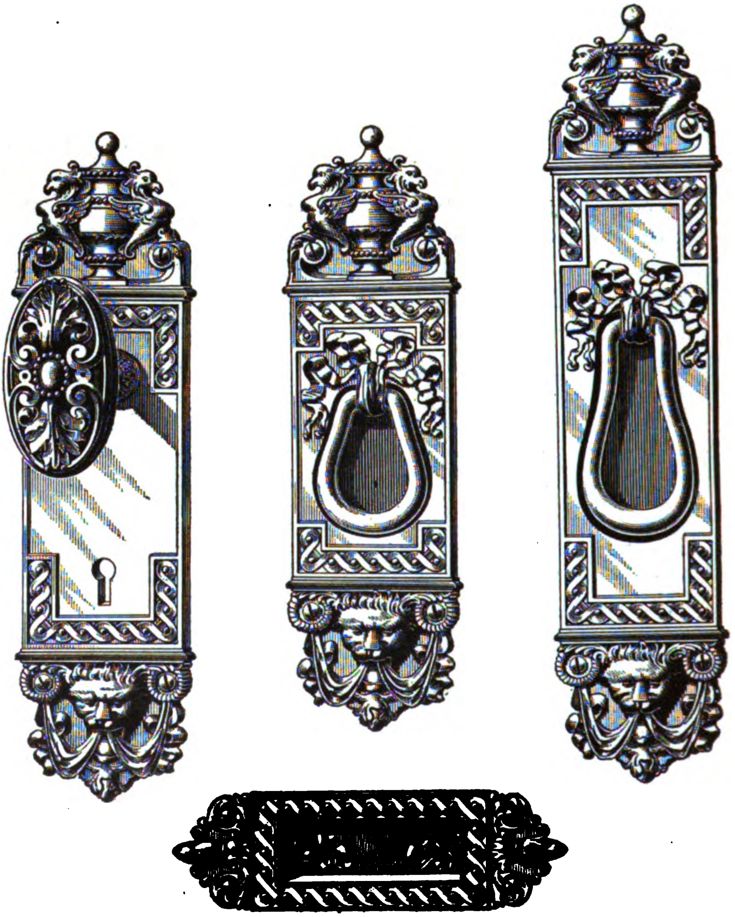


FIG. 157

In all instances, the device selected is usually introduced as the central ornament of the door knob. This ornament is also repeated on escutcheon and push plates, and generally on the larger pieces of metal work; and while it may constitute the sole feature of decoration, it usually has associated with it a border or other ornament.

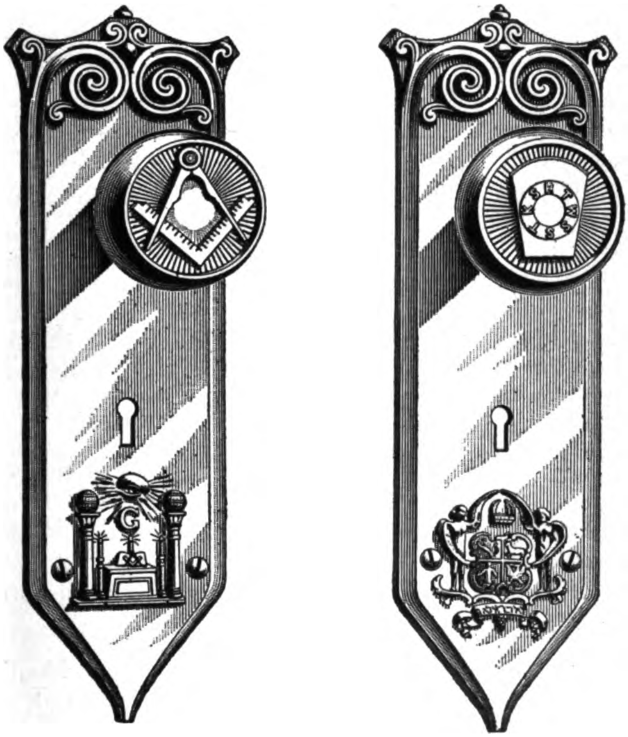


FIG. 158

The use of emblematic hardware involves the use of special designs and patterns, and thus entails a considerably greater cost than the use of standard patterns. In Fig. 157 are shown several standard ornamental designs, while in Fig. 158 are shown pieces of lock trim ornamented with heraldic, or emblematic, designs.

HARDWARE SPECIFICATIONS

119. The methods of specifying builders' hardware differ considerably. Some architects generalize and use the same form of specification for buildings of all classes, while others are more specific, and itemize all the hardware for the entire operation, giving, besides the description, the catalog number and finish.

The first method is not considered good practice, and, though it involves little work on the part of the architect, it rarely produces the best results. Thus, wherever possible, the specification should be complete and comprehensive, giving a full description of all the hardware in the building.

120. Formerly, builders' hardware could only be obtained in a few styles, and there was not much choice regarding its physical construction and mechanical operation, so that its selection could be left to the contractor or builder. Specification, therefore, usually included little more than a mere statement that the necessary hardware should be furnished and that it should be of good quality.

In recent years, however, the revolution accomplished in the designing and making of builders' hardware has elevated it to an important place in decorative art, and, simultaneously, the creating of new and higher mechanical grades has radically changed the requirements in specifications relating to this subject.

121. A few standard forms of hardware specifications that should secure good results will now be considered. For convenience of reference, these several forms are marked I, II, and III. The first two forms are probably as good general forms of hardware specifications as can be written, but, while they answer the purpose in some instances, they should not be used where it is intended to have the general contract include all the hardware, or where it is possible to prepare an itemized specification such as that given in Form III. The numbering of the paragraphs in these forms is continuous with this Section, but in practice they generally start with 1.

FORM I

(SEE GENERAL CONDITIONS)

NOTE.– Under the head of *General Conditions* preceding all specifications furnished to contractors by the architect, a series of binding requirements, reservations, and stipulations are specifically stated, and it is most essential that the contractor carefully peruse them, as he is bound by them as well as by the clauses under the heading of Hardware Specifications.

122. Rough Hardware.—Provide all the rough hardware, such as nails, screws, sash weights, pulleys, chain or cord, anchors, screw bolts, and all other material in this line necessary for the completion of the operation.

123. Finishing, or Builders', Hardware.—All fastenings and metal trimmings used on doors, windows, transoms, closets, cabinets, pantries, etc. will be furnished by the owner and delivered at the building in the quantities and at the times reasonably needed by the contractor, he to apply the same under the direction and to the satisfaction of the architect.

The contractor is to be responsible for all hardware after delivery and until the completion of the building. He shall hang all doors, properly fit all locks, etc., and return them to their original packages until after completion of the painting or finishing, when he shall place them permanently. All knobs shall be covered with Canton flannel, to protect them from injury, and all keys are to be cared for until the building is delivered to the owner. The contractor shall place all keys in their locks or deliver them to the architect with tags attached, indicating where they belong.

The contractor shall furnish the manufacturer or dealer furnishing the hardware with details of woodwork or information that may be necessary in order to understand the requirements and to harmonize the hardware with the cabinetwork, and, where interferences are discovered, to have them adjusted before the hardware is delivered.

FORM II

(SEE GENERAL CONDITIONS)

124. Rough Hardware.—Same as in Form I.

125. Finishing, or Builders', Hardware.—The contractor shall include in his estimate the sum of_______dollars ($_______) for the purchase of the finishing hardware, which is to be selected by the architect or owner and charged to the contractor. If the hardware costs less than the stipulated amount, the difference shall be deducted from his contract price; if it costs more than herein contemplated, the owner will pay to the contractor the additional amount.

The above hardware is to include all fastenings and metal trimmings used on doors, windows, transoms, closets, cabinets, pantries, etc., and will be delivered at the building in the quantities and at the times reasonably required by the contractor, he to apply the same under the direction and to the satisfaction of the architect.*

FORM III

(SEE GENERAL CONDITIONS)

126. Front-Entrance Doors.—Provide for the front-entrance doors, cylinder, mortise, front-door lock and three 5″ × 5″ loose-pin, ball-tip butts for each door; also flush extension bolts 12 inches and 24 inches long.

127. Vestibule Doors.—Provide for the vestibule doors, cylinder, vestibule latch, keyed similar to the front door, and three 5″ × 5″ loose-pin, ball-tip butts; also flush bolts, the same as specified for entrance doors.

128. Side-Entrance and Rear Doors.—Provide for the side-entrance and rear doors, locks and butts the same as specified for the front-entrance doors. Exterior basement and kitchen doors to have 5-inch, three-bolt or 4¼-inch, three-tumbler lock and mortise bolt; also three 4½″ × 4½″ butts for each door.

129. Sliding Doors.—Provide for all sliding doors, Coburn trolley hangers; double doors to have locks with astragal fronts, and single doors to have flat-front locks.

130. Double-Acting Doors.—Provide for the doors where indicated double-acting in the plans, Bommer spring hinges or floor pivots of suitable size; also push plates, door holders, dead lock, and kick plates.

131. Miscellaneous Doors.—Provide for all other doors on first floor, 4¼-inch mortise lock with metal knobs and combined escutcheons; also three 4″ × 4″ loose-pin, ball-tipped butts for each door.

132. Doors on Second Floor.—Provide for all the doors on the second floor, 4¼-inch mortise locks with metal knobs and combined escutcheons; chamber-entrance and bathroom doors to have in addition a mortise bolt. Also provide for these doors, three 4″ × 4″ loose-pin, ball-tipped butts for each door.

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*Continue Form I.

133. Doors in Attic and Basement.—Provide for the doors in attic and basement, 3½-inch mortise locks, pottery knobs, and escutcheons; also two 3½″ × 3½″ butts for each door.

134. Transoms.—All transoms throughout are to be hinged at the top or the bottom or pivoted (as indicated in the plans), and are to have $\frac{5}{16}$-inch transom lifts to extend to within 5 feet of the floor.

135. Double-Hung Windows.—The double-hung windows on the first floor are to have approved sash locks and two flush lifts; those on the second floor, in the attic, and in the basement are to have approved sash locks and two flush or hook lifts to each sash. All window stops are to be secured with flush adjusting stop-screws placed not more than 14 inches apart.

136. Casement Windows and Hinged Sash.—Provide for the casement in the lavatory and on the second floor, 3″ × 3″ tight-joint butts and suitable casement fasteners and adjusters. The basement sash are to be hinged at the top with wrought butts and are to have bolts and hooks and eyes to hold them open.

137. French Windows.—Provide for the French windows in the dining room, 4″ × 4″ butts, three to each window sash. Also provide for these windows, flush bolts, 12 inches and 24 inches on standing leaf, and mortise turnbuckles.*

138. Bookcases and China Closets.—Provide for the doors of the bookcases and china closets, 3″ × 3″ ball-tip butts, two to each door; also locks and keyplates or mortise latches and knobs, and bolts for double doors. All drawers to have drop drawer pulls, two to each drawer over 20 inches wide.

139. Pantries, Dressers, and Linen Closets.—The doors of the pantries, dressers, and linen closets are to be provided with 3″ × 3″ butts, together with elbow catches or surface bolts for double doors. Also provide rim cupboard catches or mortise latches with knobs. All drawers over 20 inches wide are to have two drawer pulls. Flour bins are to be hinged at the side or at the bottom, so as to tilt, and are to be supplied with 3″ × 3″ wrought butts and bar pull or with large T-handled cupboard turn. Place in each closet one (or two) rows of brass-plated wire coat-and-hat hooks (or, bronze-plated cast coat-and-hat hooks) to extend around all sides; these hooks are to be placed not over 12 inches nor closer than 8 inches apart. Furnish rubber-tipped, wooden-base knobs for all doors.

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* In place of the mortise turnbuckle any of the following hardware can be used: Casement fasts or locks; Cremorne bolts, locking top, bottom, and center; or, Espagnolette bars, either rim or mortise.

140. **Quality and Finish.**—All of the above hardware is to be of Blank & Co.'s manufacture, except butts for interior doors, which are to be the Stanley Work product. All the hardware on the first floor, except kitchen and service portion, is to be plain, cast-bronze metal of the design known as________, and________finish. The hardware of the second floor is to be of steel, in plain design and________finish. The hardware of the bathroom is to be of plain bronze metal, nickel-plated, while the basement, kitchen, and attic hardware is to be plain steel in________finish.

141. **Miscellaneous Hardware.**—The contractor shall furnish and apply all hardware necessary to complete the building, under the direction and subject to the approval of the architect.

142. The preceding specification is intended to meet the requirements of a residence, but may be changed so as to apply to other buildings by adding to the several items or by omitting some of them. In following the specifications just given, the specification writer should exercise great care in selecting the hardware required, using the best that can be obtained with the money to be expended. In all instances, the name, design, quality, and finish desired should be stipulated.

SELECTION, ESTIMATION, AND APPLICATION OF HARDWARE

143. No other material entering into the construction of a building will pay a larger return in satisfaction, comfort, and permanent economy for the time and care devoted to its selection than the finishing hardware. The range of choice and quality has become too great for the selection to be left to the general contractor under an omnibus specification, and the practice of according to it the benefit of careful and discriminating selection by the architect or client, or both in consultation, is rapidly becoming general. Hardware has become a factor of utmost importance in the interior decorative scheme of the modern building, and its selection demands at least the care accorded to other elements of interior decoration.

The method that should be employed in the selection and purchase of hardware depends primarily on the existing conditions. If the building is intended for the purpose of sale or renting, or if cheapness is the dominating factor, then a competitive method may be expedient; but if the client intends it for personal occupancy or for permanent ownership, then competitive bidding is sometimes not productive of the best results.

In all cases, a preliminary examination should be made of the makes and grades of the commercial hardware available, and the amount that it is desired to expend on this item should be decided on. The process of selection is greatly facilitated by the elimination of articles outside of the grades selected. When the maker's grade of goods has been decided on, the next step is to select in detail the articles, designs, and finishes to be used in each room, floor, or division of the building, making such notes of the decisions so reached as will be convenient in framing the hardware specification, or schedule.

144. Allowance for Finishing Hardware.—Architects are constantly called on to prepare preliminary estimates on proposed buildings, to assist clients to determine whether they can afford to build. For this purpose, the architect possesses an approximate knowledge of the cost of excavation, masonry, woodwork, etc., so that the necessary expenditure may be computed with a fair degree of accuracy. Builders' hardware, however, does not readily admit of accurate preliminary estimating, and in many cases the architect merely specifies the sum to be expended for finishing hardware, stating that selections are to be made by himself or his client later, as the work progresses. This system is found in many instances to be satisfactory to all—architect, client, and builder.

The cost of the hardware usually bears a fairly constant ratio to the total cost of various types of buildings. The following figures, which are based on experience, indicate the range in this ratio under ordinary conditions. This schedule gives the ratio of cost of finishing hardware to the total cost of the building, land excluded.

TYPE OF BUILDING	PER CENT.
Hotels, large	1.00 to 1.5
Hotels, small	1.50 to 2.0
Apartment houses	1.50 to 2.0
Office buildings	1.00 to 2.0
Office buildings, fireproof	.50 to 1.5
Public buildings	1.50 to 2.0
Libraries	.75 to 1.5
Hospitals	.50 to 1.0
Residences, city	1.50 to 3.0
Residences, country	2.00 to 4.0

145. Taking Off Hardware.—The compilation of the estimate schedule of finishing hardware for a building must be made from the architect's plans and specifications. Therefore, where possible, this work should be done by a hardware expert or salesman, or by some person who has the ability to read drawings easily and accurately and who is capable of exercising thoroughness in every detail of the work. The first step should be to study the specifications relating to the general work, and especially that portion relating to hardware and carpenter work, to see whether the latter embodies facts that affect the hardware. If such is the case, notes should be made of the fact, and in many cases, by following this rule, miscellaneous information can be gathered that will be invaluable to the contractor and will prevent much doubt as to requirements. The drawings should then be examined, to gain familiarity with the building, the arrangement of the interior, and other details. Having thus acquired a general understanding of the whole subject, the compilation of the quantities may begin.

146. The list of hardware should be compiled in a systematic manner, beginning at a definite point in the building and progressing through the several rooms and floors in a definite order. This will insure the inclusion of every part of the building and the careful consideration of every opening or other place where hardware is required. For example, in the case of a residence, it is customary to commence at the front entrance, including the front and vestibule doors, passing thence to the hall, taking each room on the first floor in due order, passing to the second floor and taking each room on it in like order, and so on until each floor is covered. The attic and basement are usually left until last, because they require a simpler class of goods. The same general system can be followed in the case of hotels, office buildings, apartment houses, etc., the essential point being that an orderly method be followed. The rooms should always be taken in natural sequence, and all openings of similar character totaled and again counted on the drawing, so that the chances of omission are minimized.

147. In the case of doors, it is necessary to make note of the size and thickness, the hand, and the bevel, or rabbet, as required, using in all cases three butts on all exterior doors, and also three butts on all interior doors 7 feet or more high. The size of the butts should in all instances be sufficient to cause the door to clear the trim. The width of stiles and the general construction of the doors should be noted, paying particular attention to the front-entrance doors, as architects sometimes design these regardless of the hardware that is to be used on them. Frequently, a careful scaling and scrutinizing of elaborately designed doors will show a shelf effect returning back to the lock stile, covering nearly half its width, just about where the lock should be placed. Such defects can be remedied easily, if observed in time, by directing the architect's attention to them.

In the case of sliding doors, it should be noted whether they are single or double, what is to be the character of the hanger, or rail, and the length of the run, and whether the door has a flat or a half-round astragal. The width of the stile and the size of the friction strip should also be noted, so that the hardware will not conflict with the woodwork, molding, etc., as, where necessary, special backsets can be procured on sliding-door locks to overcome this trouble.

Where double-acting doors are shown, always take note of the thickness, width, and height, also of the width of the lock stile and the height of the bottom rail, so that, if push plates or kick plates are required, the suitable dimensions for them can readily be estimated. The dead locks for these doors should be ordered with oval fronts for single doors and oval fronts and strikes for double doors, to allow for neat fitting to the rounded edge of the doors. Where kick plates are required for double doors of this character, flush bolts should be mortised into the edge of the door, so that the lower bolt will not interfere with the kick plates.

148. In stating the information for windows, full details are needed as to whether they are single- or double-hung, French casement, stationary, or ordinary casement. Double-hung windows 20 inches or less in width require only one sash lift. Extra-wide windows, such as those over 36 inches, should have either bar lifts or two extra-heavy hook sash lifts. The window stops should be studied in detail, so as to estimate the number of screws that will be required for each window. In the case of French windows, it is well to determine the height, the width of the stile, whether the joints are rabbeted, beveled, or flat, the hand, and whether the windows swing in or out; detail cross-sections through head-jambs, casing, and lock stiles should also be procured if possible. In casement sash, the pivoting should be noted, so as to determine whether it is vertical or horizontal; the swing should also be observed, and if the sash are to be hinged, determine whether the hinges should be placed at the top, the bottom, or the sides. As in the consideration of doors, the thicknesses and sizes of all casements should always be noted. Sections through the jambs, trim, and stiles should be taken at the points where the hardware is to be applied.

149. In order to determine the kind and length of the lifters to be used on the transoms, it is necessary to note the distance from the floor to the center of each transom, also whether they are to be pivoted or hinged from the bottom or the top, and how they are to swing. The cross-section through side jambs and casings should always be ascertained, in order to see that the hardware will be suitable to meet the conditions of the trim.

150. It is necessary to learn all details of the pantry, including the thickness and height of doors, whether they are double or single, and the number of each kind. Note all drawers; those under 20 inches in width require only one pull. The details of the flour bins should be examined to determine whether they are to be hinged at the bottom and are to tilt, or whether they are to be curved on plan and are to be hinged at the side, as each condition requires different hardware.

151. Where unavoidable interferences are discovered, or where the plans and specifications are obscure or defective, a note of the facts should be made, and when all such matters have been collected, they should be submitted to the architect for his decision as a basis for final determination.

152. **Application of Hardware.**—Owing to the fact that hardware has become more intricate in its manufacture and therefore more complicated in its construction, it is found that the proper amount of intelligence is not always exercised in its application. Frequently it is applied so carelessly that the hardware practically loses its most essential features. In the case of mortise-lock sets, all of the better grades are made with easy springs, so that the door will close gently and surely. However, this one feature alone is sometimes obliterated by careless application. The trouble in this direction is principally caused by the carpenter fitting the lock into the door untrue, and then screwing the escutcheons to the doors out of plumb and alinement. This causes the knob shanks, when rotated, to bind, or stick, in the sleeve, or collar, of the escutcheon, thereby holding back the latch bolt after the latch is withdrawn into the lock case. It is also found that proper adjustment is seldom given to the knobs and spindles passing through the escutcheons. In many cases when the hardware is applied carelessly, the owner, not knowing the real cause of the trouble, condemns the best hardware as being cheap and unsatisfactory.

In the application of cylinder locks for either front doors or office doors, it is found that a great amount of inexperience is shown by the average mechanic. In some cases, the locks are inverted, with the cylinder below the knobs, when it is designed to be above; also, sometimes, in reversing a front-door lock with night work, good judgment is not always used.

153. Such troubles as those just described can be easily overcome, and if the methods of applying hardware that follow are strictly adhered to, satisfactory operation will be assured.

Reversing the ordinary mortise, or rim, lock requires no special ability on the part of the workman, as the operation consists of merely taking off the cap and turning over the latch bolt. Where, however, a mortise lock is to be applied, care must be exercised so that it will work properly. First fit the lock into the door at the proper height from the floor, making the mortise large enough for the lock to enter easily. Bore the holes for the knob and the key, and insert the screws in the lock face and drive them home. Now take the escutcheons, or roses, and knobs and apply them to the door, carefully adjusting the knobs and spindles so that there is only slight play in the length. Then true up both escutcheons, by holding one with the thumb and the other with the fingers. When this much is accomplished, turn the knobs right and left to see whether they work properly; if they bind in the collar, adjust the escutcheons a trifle, vertically or horizontally, until the knobs rotate back to the original position in both directions without binding. By using a scratch awl and punch carefully, the exact center of each screw hole may be located, and by holding the awl perfectly true the screws will be started true. The escutcheons may now be released and the screws driven home. If this method is carefully followed, workmen will find that the latch bolt will work properly in almost every case. Always try the knob, when the application is completed, by rotating both to the right and to the left, and if found to bind, always make the proper adjustment before leaving the work.

154. In fitting strikes to the jambs, it is suggested that the workman locate them as low as possible, to conform to the locks, leaving the margin in the strike below the lock bolts. Doors in new buildings are liable to sag slightly, and if proper allowance is not made, the strikes may have to be readjusted, sometimes even before the contract is completed.

It is also necessary for the carpenter or superintendent to caution the painters not to paint or varnish any hardware, especially the lock faces, as this will also retard the operation of the latch bolt. As previously stated, the hardware should be fitted to the work and then replaced in the original packages, so as to protect it from abuse and damage, applying it permanently only after the painting is completed.

155. In applying cylinder, or front-door, locks, the conditions are still more difficult to overcome. When reversing cylinder locks that have swivel spindles, unscrew the cap and reverse the latch bolt; also, reverse the hubs, that is, the parts of the lock through which the spindles pass. Cylinder locks should always be mortised into the door at the proper height from the floor, and the holes for the cylinders and knob spindles then made. Insert the lock into the mortise, but do not put screws into the face; then apply the escutcheons and adjust the knob, taking care that the swivel of the spindle centers at the joint in the split hub. Now proceed to screw in the cylinder to its full extent, so that the cylinder collar is held rigidly between the cylinder and the escutcheon, and the cylinder is perfectly vertical. Then set the cylinder adjusting screw, and insert the wooden screws in lock face and drive them home with the screwdriver. Hold and adjust the escutcheon so that the knob will rotate back and forth automatically without friction, starting the screw holes with an awl. If the doors are made of hardwood, an automatic drill will have to be used to bore the screw holes. In such a case, follow the directions just given regarding escutcheons;

then start the holes with a scratch awl while still holding the escutcheons, and enlarge the holes with the drill. Screws that are off center, when driven home into the countersinking, will surely draw the escutcheon so that the knobs will bind and thus destroy the most desirable feature of the lock.

156. Mechanics will find that the better the grade of the hardware, the more care must be taken in its application. Hardware for fine buildings is generally furnished with high, or bracket-bearing, collars on escutcheons and screwless knobs for adjustment without washers. These are fitted and turned carefully, so that there is very little play between knob shanks and collars, and for this reason they bind more readily when improperly applied. The mechanic should try the lock in every possible way before leaving the work. He should set the stop in the lock face, to be sure that swivel spindles are adjusted properly, and also insert the key in the cylinder, to see whether it operates smoothly while operating both bolts.

SCHEDULES AND DRAWINGS FOR THE HARDWARE CONTRACTOR

157. Hardware Schedules.—The contractor for the hardware usually takes off his own bill of material from the general drawings and the specifications furnished by the architect. However, the architect will sometimes supply the hardware schedule and obtain prices for the same direct from the dealer, thus saving the owner the general contractor's profit and insuring bids based on material of uniform character and quality. It is well, therefore, to give some thought to the preparation of the schedule, so as to insure a good classification and to avoid omissions.

In drafting a schedule of hardware required for a building, it must be compiled from a copy of the hardware specifications and a list of all openings, cabinets, etc. that has been taken from the drawings. The schedule should be subdivided primarily into building sections, such as *first floor*, *second floor*, etc., as headings. Under these headings, each opening or group of openings in each room or division should be listed. Under the name of each opening or series of openings should be grouped all the hardware required, itemizing each and every article necessary and stating the quantity, numbers, sizes, or dimensions, design, and finish.

Schedules thus prepared are readily priced for estimating, and such classification eliminates the possibilities of omissions. Besides, the order can be executed by the manufacturer in exact conformity with the instructions, the hardware for each opening can be combined in a separate package, and each package clearly labeled to indicate its contents and the room or opening to which it belongs. The following shows a typical form of schedule:

FIRST FLOOR

One Pair of Entrance Doors, 2′ 8″ × 7′ 6″ × 2¼″ Rt.-Hd. rabbeted.

1 cylinder, front door, Set No.______.	Plain bronze metal.
1 push button, No.______.	Plain bronze metal.
2 extension flush bolts, No.______, $\frac{1}{12}$″, $\frac{1}{18}$″.	Plain bronze metal.
3 pair of butts, No.______, 5″ × 5″.	Plain bronze metal.

One Pair of Sliding Doors, Hall to Parlor, 2″ astragal face, 1½″ friction strip.

1 set of locks, No.______, 3″ backset.	Plain bronze metal.
3 dozen countersunk screws and washers.	Plain bronze metal.
2 sets of antifriction, noiseless, parlor-door hangers and track, complete, No.______.	

Pantry Cupboard.

2 pair of doors, 1⅛″; 2 single doors, 1⅛″.	
1 tilt flour bin; 4 drawers (2 narrow).	
6 pair of butts, No.______, 2½″ × 2½″.	Plain bronze plated.
1 pair of butts, No.______, 3″ × 2½″.	Plain bronze plated.
2 elbow catches, No.______.	Japanned.
4 cupboard turns, No.______.	Plain bronze plated.
7 draw pulls, No.______.	Plain bronze plated.

SECOND FLOOR

Ten Doors, $\frac{2}{8}$″ × 7″ × 1¾″, 6 R. H., 4 L. H. transom, top-hung.

10 inside lock sets, No.______.	Plain bronze metal.
15 pair of butts, No.______, 4½″ × 4½″.	Plain bronze plated.
10 pair of butts, No.______, 3″ × 2½″.	Plain bronze plated.
10 transom lifts, No.______, $\frac{5}{16}$″ × 4″.	Plain bronze plated.
10 wooden-base knobs, 2½″ diameter.	

Double-Hung Windows

10 sash fasts, No.______.	Plain bronze metal.
20 sash lifts, No.______.	Plain bronze metal.
10 sash sockets, No.______.	Plain bronze metal.
4 sash hooks, No.______.	Plain bronze metal.
10 dozen adjusting screws and washers.	Plain bronze metal.

The foregoing schedule is merely intended as an example of a classified, brief, and at the same time comprehensive hardware schedule. A schedule of this kind shows, almost at a glance, the nature of the hardware to be supplied, and if prepared by the architect, should tend to procure bids based on uniform requirements.

158. Detail Drawings for the Hardware Contractor.—In some architects' offices, it is the practice to provide, on a single detail sheet, cross-sections of every type of door stile in the building. The time required to make such a drawing is slight, while the results accomplished are most useful. Copies of this drawing are furnished to the contractors for the cabinet trim and to the hardware contractor, so that each of them will have identical information and that the work will assemble properly when the hardware is put in place.

Such drawings should show the dimensions of the transverse sections of the vertical stile, or lock stile for each door, also the overlapping, if any, of panel moldings, together with the shape of bevels, rabbets, astragals, and any other details affecting the size and location of locks, hinges, butts, etc. The hand of the doors is usually, and better, indicated on the floor plans. A further argument is that the character and dimensions are liable to be overlooked when arranging the paneling of doors; whereas, both should be considered. The use of narrow stiles, special rabbets, and astragals, shelf effects, friction strips, etc. is resorted to without sufficiently considering the disadvantages that result from the contracted space in which the lock and its trim must be placed. Where the items just mentioned are proposed, the architect should ascertain what locks are available and should provide space for those selected. Special locks are always expensive, while a cramped space precludes the best construction.

GLASS AND GLAZING

159. Single- and Double-Thick Common Glass. In the manufacture of the ordinary window glass used in building construction, the glass is first blown in cylindrical form and then cut and flattened, after which it is reduced to salable sizes for shipment. Owing to this method of manufacture, the percentage of first-quality glass is small, the larger proportion of the product being second or third quality. All glass of this kind is wavy or uneven and also has a slight bow, or curve, to its length that is impossible to overcome when making. The only difference in the qualities of common glass is in the amount of the imperfections that it contains. These imperfections consist of bull's-eyes, blisters, scratches, and streaks that distort objects seen through the glass.

The better grade of common glass is manufactured in what are called continuous tanks, which are heated by natural gas. This glass is put up in boxes containing 50 square feet. **Single-thick glass** runs from thirteen to fifteen lights to 1 inch of thickness, and **double thick** from eight to ten lights to the inch. Single-thick glass above 20 in. × 24 in. in size should not be used except for work of a speculative nature. The ability to distinguish single and double thick and the various qualities of glass can only be acquired by observation. In judging glass, it is well to remember that small lights free from defects or uneven surfaces may be obtained much more easily than large ones.

160. Ground or Sand-Blast Glass.—Common or plate glass, the surface of which is made obscure by the process of grinding, is called **ground glass.** This treatment, however, does not injure the diffusing qualities of the glass.

The **sand-blast process** of treating glass produces results similar to grinding. As the name implies, sand is blown against the glass under high pressure and thus makes numerous small cuttings on its surface, producing the appearance of ground glass.

161. Chipped Glass.—The glass illustrated in Fig. 159 is called **chipped glass,** and is manufactured in the following manner: The glass is first given a coat of glue and is then placed in a heated receptacle; this process tends to contract and curl the glue, so that when it dislodges itself from the glass, the cohesion will draw or chip off particles of glass, leaving the surface uneven and showing a design similar to that on a frosted window light. Chipped glass can be procured in either the single or the double process

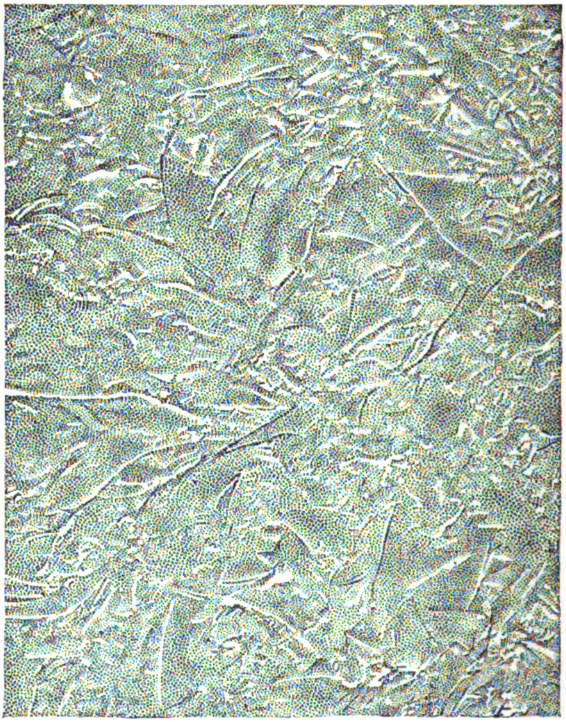

FIG. 159

(i. e., with a single or a double chipping); and these processes are adaptable to either sheet or plate glass, white or colored.

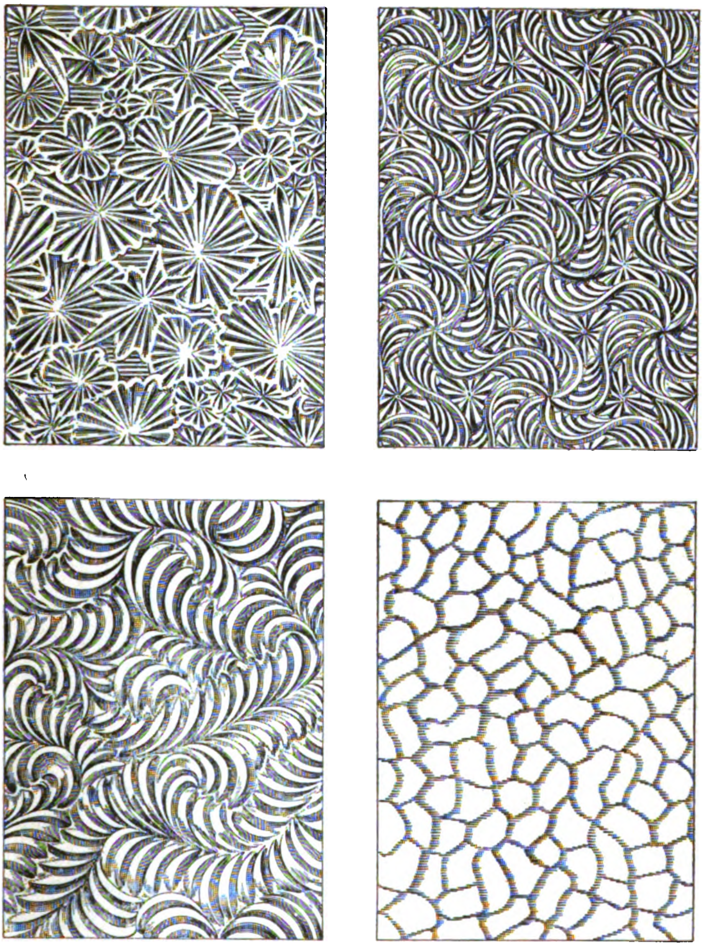

Fig. 160

162. Figured Rolled Glass.—Glass known generally as **figured rolled glass** is manufactured for use in offices, public buildings, and private residences where a glass is required to intercept the vision and still diffuse the light.

This glass has practically supplanted the varicolored cathedral glass previously used, because of its obscurity without reducing the quantity of light. Figured rolled glass is made in various artistic designs, several of which are illustrated in Fig. 160, and is $\frac{1}{8}$ and $\frac{3}{16}$ inch in thickness. This glass is inexpensive; the prices range from 15 to 25 cents per square foot.

163. Plate Glass.—The process of manufacturing **plate glass** is radically different from that of common sheet glass. The latter is blown, while the former is cast in large sheets and placed in annealing ovens to cool. When taken from the ovens the glass is rough and opaque, but it is afterwards ground and polished to make it transparent, the polishing being the most delicate process in its manufacture. Plate glass glistens like a mirror and reflects like one; objects seen through it are sharp and clean-cut; it has no imperfections or wavy effects, and does not distort and deform objects as does sheet glass.

164. Beveled Plate Glass.—The term **beveled plate** is applied to plate glass the edges of which are ground and polished to form a bevel, or border, around the glass. Plate glass finished in this manner is much used for glazing entrance doors and for ornamental work. The additional cost for beveling is slight compared with the effect resulting therefrom.

165. Floor and Skylight Glass.—**Floor glass** is made only from rough rolled or hammered glass in $\frac{1}{2}$-, $\frac{3}{4}$-, and 1-inch thicknesses. The prices range from 30 cents to $1 per foot, according to the thickness.

Skylight glass is similar to floor glass, but can be procured in $\frac{1}{8}$-, $\frac{3}{16}$-, $\frac{1}{4}$-, and $\frac{3}{8}$-inch thicknesses, and in either ribbed or roughened surfaces. This glass is inexpensive, the prices ranging from 8 to 15 cents per square foot. Large quantities of skylight glass are used for mills, skylights, and various other purposes, but it is not used as a fire-retardant, as wire glass has entirely superseded it for this purpose.

166. Wire Glass.—Glass with wire embedded therein, as illustrated in Fig. 161, is made either ribbed, rough-rolled, "maze" design, or clear, polished plate. The wire netting is embedded in its center during the process of manufacture, thus producing a very strong glass that is a good fire-retardant. The temperature at which the wire is embedded in the molten glass insures cohesion between the metallic netting and the glass, and the two materials become as one; thus, if the glass is broken by shock, by intense heat, or from some other cause, it remains practically intact. Wire glass combines the strength of the wire netting and the glass plate, and the wire is so thoroughly covered as to obviate the possibility of rust or corrosion. This glass possesses extraordinary strength; a piece $\frac{1}{4}$ inch thick is as strong as ordinary glass of twice that thickness. When wire glass is broken, it will not scatter like plate or skylight glass; consequently, it finds extensive use for overhead work, where falling glass due to accidental breakage would be a source of danger.

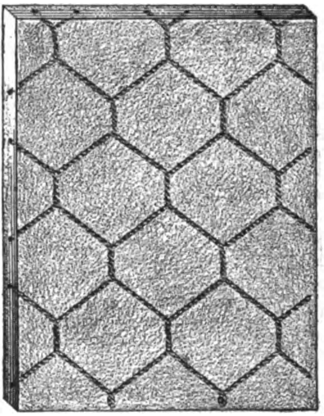

FIG. 161

Wire glass is made $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch thick, and up to 40 inches wide and 100 inches long. This glass is sold at from 30 to 40 cents per square foot for rough, ribbed, or maze pattern, according to the thickness, while polished wire glass costs either 60 cents, 95 cents, or $1.25 per square foot, according to the dimension of the light. Wire glass is practically burglar-proof and missile-proof, and when set in approved metallic frames forms a most efficient fire-retardant window. In its use as a fire-stop, it possesses advantage in that it does not hide the incipient blaze like steel-plate or tin-lined shutters. Windows glazed with wire glass require no shutters for protection, but an opening may be made in it by a blow from a fire-ax. Wire glass as a fire-retardant is approved by the various boards of fire underwriters, and it may be used for windows, skylights, and other exterior openings exposed to fire hazard.

167. Prisms, or Prismatic Glass.—When a ray of light passes from air to glass, it undergoes the change in direction called *refraction*. The knowledge of this property of light is utilized in the design of **prismatic glass**, an example of which is illustrated in Fig. 162. Prisms are made of clear crystal glass, with the outer side usually plain. The inner side, however, is formed into prisms of a great variety of angles made to suit the several conditions under which the lights may be used. Prism plates are made in two styles: *Pressed prism plates*, which are composed of 4- or 5-inch pressed lenses that are glazed together with a drawn zinc or copper bar, the several bars forming a frame being brazed together electrically, and *rolled*, or *sheet*, *prisms*, which are first rolled in large sheets and then cut to size.

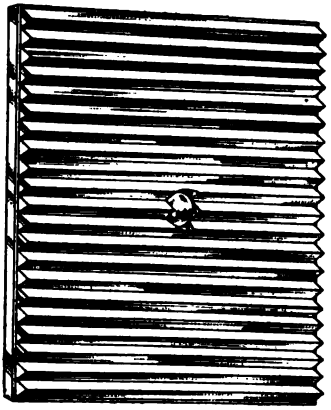
FIG. 162

Under average conditions, the direct light from the sky entering a room through sheet or plate glass strikes the floor within a few feet of the window and is mostly absorbed. For this reason, the rear part of the room is dark. By the installation of prisms at the window openings, however, the direction of the entering light is changed and projected horizontally into the room. Prisms do not create light; they simply distribute and diffuse the excess light at the window. Under certain conditions the effective light in a room may be increased fifty times by the installation of prisms. In Fig. 163, the arrows *a* show the direction of the lowest rays from the sky over the cornice of the opposite building, striking the prism plate at the floors. These arrows also indicate vertical rays, striking canopies and skylights, while the arrows *b* show the directions of the rays just mentioned after passing through the prism plate; also, the manner in which the light rays are projected into the building.

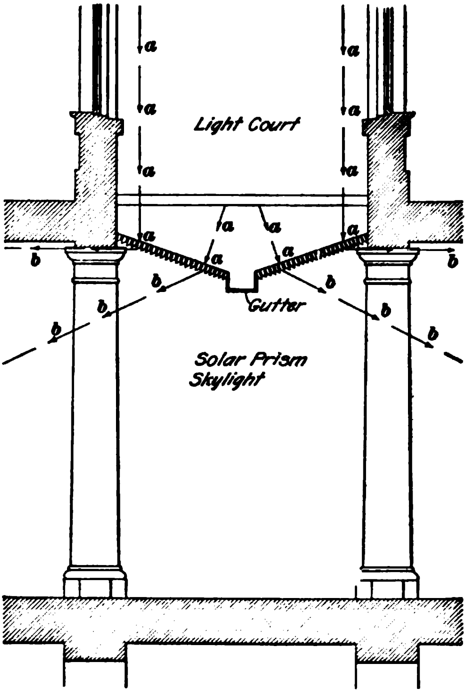

FIG. 163

168. Vault Lights for Basement, or Cellar, Lighting.—Where the sidewalk and the basement ceiling are nearly on a level, basement rooms can be successfully lighted by the installation of **vault lights**, or *glass pavement tile.* The ordinary method is to use plain, round, or square lenses, which are set in iron or concrete in iron frames, as illustrated in Figs. 164 and 165, though vault lights are now made with the supporting material of reinforced concrete. Where the ceiling is low or the room at all deep, the system in which plain lenses are used is unsatisfactory, as the direct light from the sky in passing through the lens strikes the floor immediately underneath.

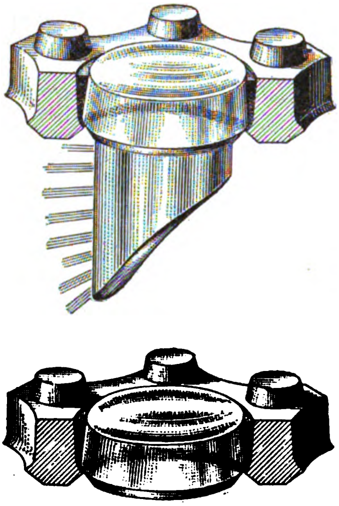

FIG. 164

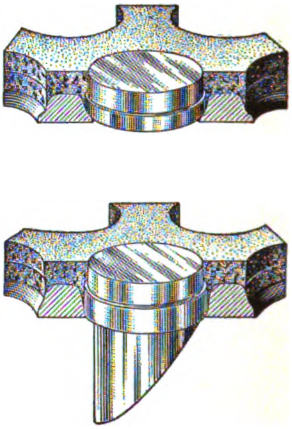

FIG. 165

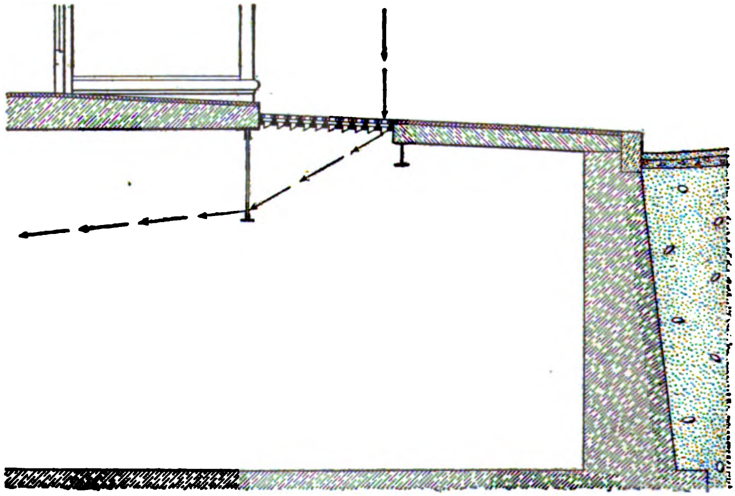

FIG. 166

The more modern method is to use prism tile set in the necessary frames. The prism receives the direct light from the sky on the upper face and turns, or refracts, it back into the basement, as illustrated in Fig. 166. Where the head-beam or other obstructions interfere with the deflection of light direct from the prism, it becomes necessary to use in connection with the skylight or canopy just described an independent vertical frame of window prisms of varying angles. These prisms intercept the light from the pavement tiles and project it into the basement, thus utilizing the light to the maximum advantage.

169. Glazier's Points.—A necessary adjunct in glazing with putty is the sheet-zinc, triangular **glazier's points**, as illustrated in Fig. 167. These points are made in six sizes, which range from No. 000, the largest, to No. 3, the smallest. They are also made in somewhat similar shape, called *sharps*, but this type is not so popular as the *triangle point.*

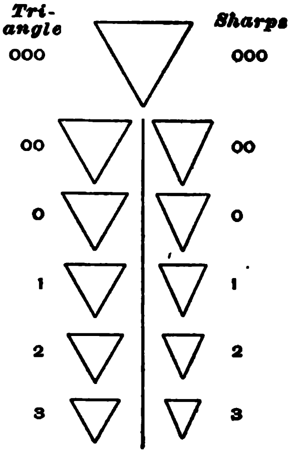

FIG. 167

170. Grades of Putty. Putty is usually graded as follows: *Commercial*, a very cheap grade; *pure*, a medium grade; and *strictly pure*, the best grade, which is made of pure whiting ground in linseed oil. The cheaper grades are made in the same manner, but with an amount of adulteration, either in oils or whiting, commensurate with the cost. Therefore, the cheaper the putty, the more it is adulterated, and none but strictly pure should be used when good results are desired.

White-lead putty is in a class by itself, and costs about twice as much as strictly pure whiting putty; but where permanent glazing is required, its use will show handsome returns on the investment.

ROOFING

ROOFS

ORIGIN AND DEVELOPMENT

HISTORICAL INTRODUCTION

1. The origin of house roofing is to be found in the endeavor and determination of man to provide for his physical wants and comforts. Man, in a primitive and uncultivated state, commenced by rudely imitating birds and beasts in his attempts at shelter seeking and self-protection, constructing or appropriating caves, or building arbors of twigs and branches. The hunter had recourse to the cave, the nomad to the tent and bower, while the agriculturist built himself huts of dried turf. The skins of beasts preceded the tent and the tent developed the bell roof of the Chinese and Tartars, an illustration of which is shown in Fig. 1.

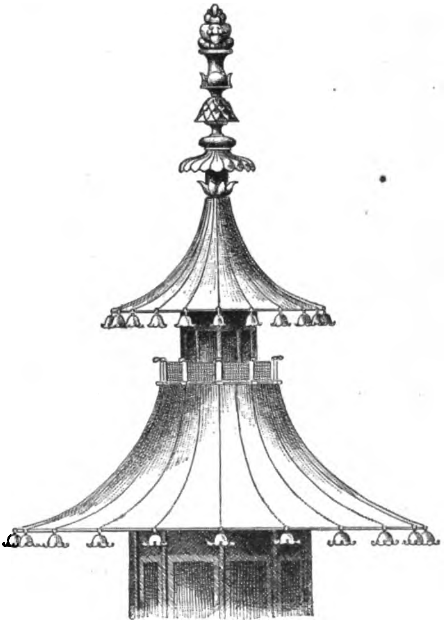

FIG. 1

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2. Tents.—The skin tent was much used by the Arabs, and was generally made of goatskin, dyed black, spread over two or more poles about 8 or 9 feet long. The Australians, the tribes of the Polynesian Archipelago, the Caribs, and the nomad tribes of North and South America were tent dwellers.

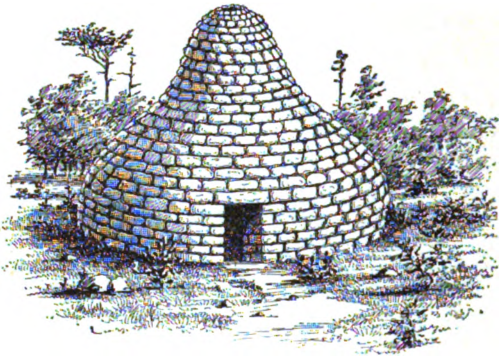


FIG. 2

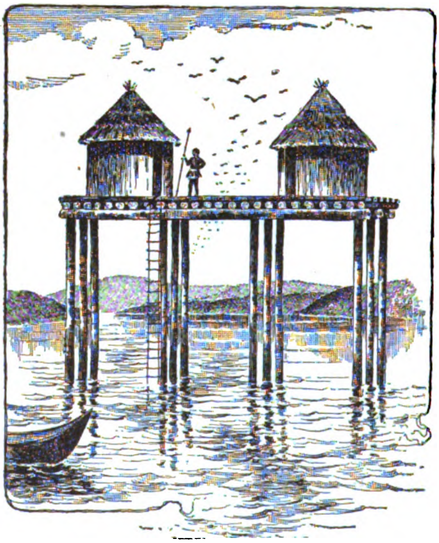


FIG. 3

3. Huts.—After the tent, came the hut of wood or stone. The construction of the stone hut, or beehive, so called from its shape, which is shown in Fig. 2, was a combination of both house and roof, and may still be found in parts of the British Isles. It is supposed that this period was followed by the cliff and the lake dwellers. The former hewed out caves in cliffs to form a covering that would protect them from both the weather and the attacks of enemies.

The lake dwellers seem to have been imbued with similar purposes, for they cut down trees, which they drove into the bottom of lakes, and on these built huts with thatched roofs, as shown in Fig. 3. The lake dwellers' huts were very picturesque and were mostly found in Italy, Sweden, Switzerland, and Ireland. In Mexico, in South America, and in Africa, there are still numerous colonies of lake dwellers.

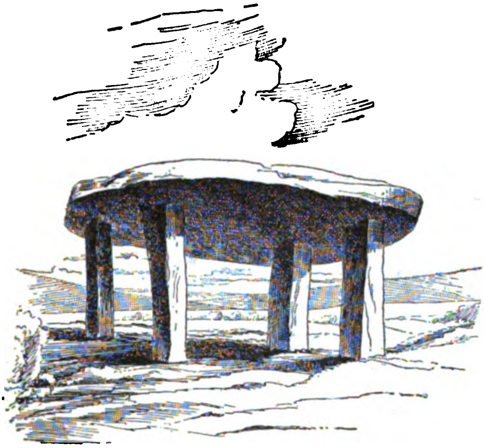


FIG. 4

The most noted cliff dwellers' works are in Morocco, in the Old World, and in Arizona and New Mexico, in the New World.

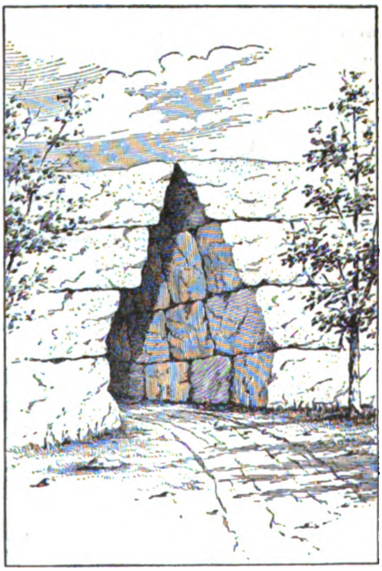


FIG. 5

4. Stone and Earth Roofs.—The next form of covering was probably that of large stones, or monoliths, over which flat stones were placed, as shown in Fig. 4. In connection with stone roofs, the device of corbeling out each course on the two opposite sides until they met at the top, as shown in Fig. 5, was also resorted to.

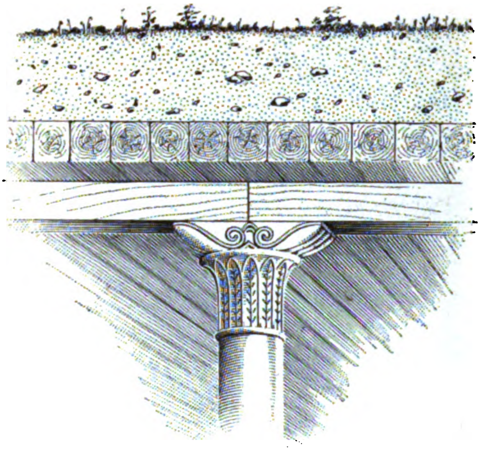


FIG. 6

The first real roof covering after the thatch and bough roofs of the nomads was erected by the Assyrians. These were built of squared timber placed close together, and the upper surface was covered with thick layers of earth, as shown in Fig. 6. These roofs are said to have been beautified in many cases by varied vegetation, such as flowers, etc.

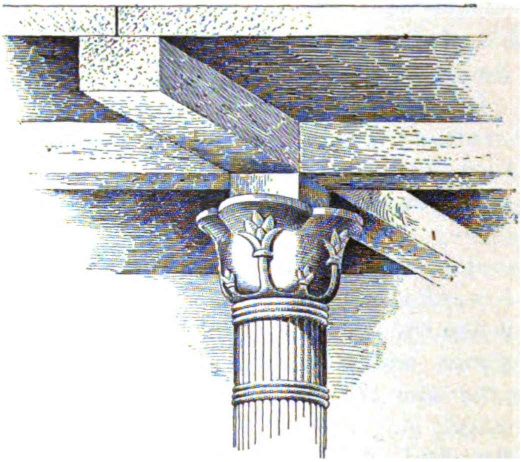


FIG. 7

The earlier Egyptians and successive peoples constructed their roofs of flat slabs of stone, which were supported on stone lintels or beams resting on columns, as shown in Fig. 7. These roofs, in turn, were succeeded by tiles on boards or vaulted stone roofs.

5. Tile Roofs.—The history of tiles as a roof covering is too extended to completely review; nevertheless, tiles deserve special mention, because they are the most desirable and the most serviceable materials used for roofing. The earliest mention of them occurs perhaps in the Book of Kings, in the description of Solomon's Temple. They have been used in China from a period of such remote antiquity as 2,000 years B. C. Whether the manufacture of roofing tiles was carried from China to India and Persia, and thence to Egypt, Phœnicia, and Assyria, or whether it was a native and spontaneous product of these peoples, who were the first to develop the artistic resources of the human intellect, is a disputed question. It was from these countries, undoubtedly, that the art found its way through Greece into Europe, where it was soon carried to great perfection. Tiles were used by the Grecians, Romans, Venetians, and most nations of Southern Europe. The history of tiles, during the intervening time, from the Romans to the Mussulmans, Saracens, and Moors, is not known, but its revival is due to the Moors. From 732 to 1492, Spain was famous for its potteries, as were also India and Asia Minor. The tiles most used were flat tiles turned up at the edges, with a row of inverted semicylindrical ones placed over the joints.

In the middle ages, tiles were the principal covering, though stone slabs were much used and laid in the same manner as shingles, supported on barrel-vaulted roofs.

6. Types of Roofing Tile.—In the following outline, the types of roofing tiles are illustrated in a general way, and mention is made of those by whom they were originally used.

Tiles are supposed to have been first brought to America by the German settlers in Pennsylvania, and were of the flat variety. The pan tile was brought by the Dutch, who settled along the Delaware River in New Jersey; and the Spanish tile, by the old Jesuits to California.

For the *normal* (Asiatic) type of tiles see Fig. 8. Those shown at (*a*) were used in the Orient, ancient Greece, and Italy; those shown at (*b*), in China and India; those shown at (*c*), in the Orient, Asia, and the Mediterranean countries, south of latitude 44°; those shown at (*d*), in Greece and Italy, ancient and modern. For the *pan* (Belgic) type see Fig. 9.

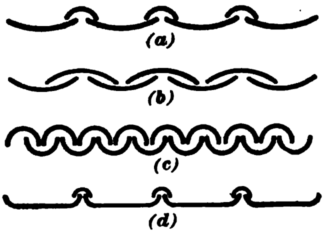


FIG. 8

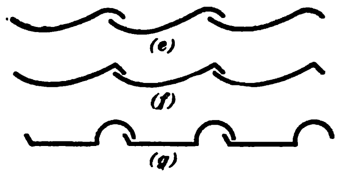


FIG. 9

Those shown at (*e*) were used in England and Scandinavia; those shown at (*f*), in Belgium, Holland, Scandinavia, Japan, and Java; those shown at (*g*), in various modern countries. The *flat* (Germanic) types were used in Germany, Austria, Hungary, Poland, Switzerland, France, and England.

7. Metal, Wood, and Slate Roofs.—**Metal roofs** may rightly be termed modern roofs. Lead was the first to be introduced; copper, zinc, tin, and galvanized iron followed. Lead and copper were used in medieval times for covering roofs, but it was not until about 1760 that they came to be used as a general covering for large buildings.

Wooden shingles and **slate** were known at an early period, and were used in the form of slabs having considerable weight. Edward II gave an order, in 1314 A. D., to replace the shingle roofs of certain government buildings with slate, thus showing that, even at that time, both were extensively used, though it is commonly supposed that wooden shingles are of a very much later date.

Tin, the most extensively used roof covering in the United States, was originally a North German product, and was made there as early as 1600; it next was made in Bohemia, 1620; at Pontypool, Wales, in 1670; and at Mausvaux, France, in 1714; but not until recently, in the United States.

GENERAL TERMS AND DEFINITIONS

VARIETIES OF ROOFS

8. The different styles, methods, and materials used for roofing, as well as the application of each to the particular form or style of roof to which it is best adapted, will be

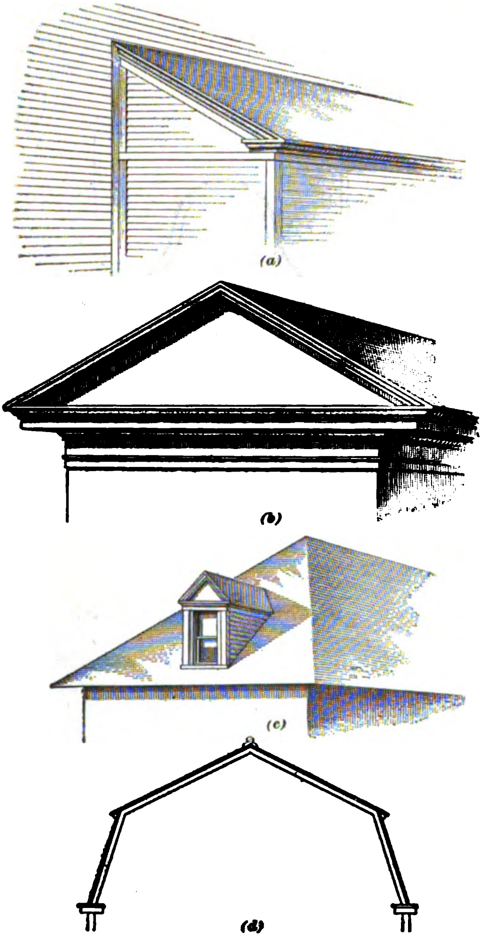


FIG. 10

discussed in the order of their importance and historical development.

9. Roof Names.—The names of roofs are determined: (1) by their *style;* (2) by their *outline;* and (3) by their *angle of inclination*, or *pitch*.

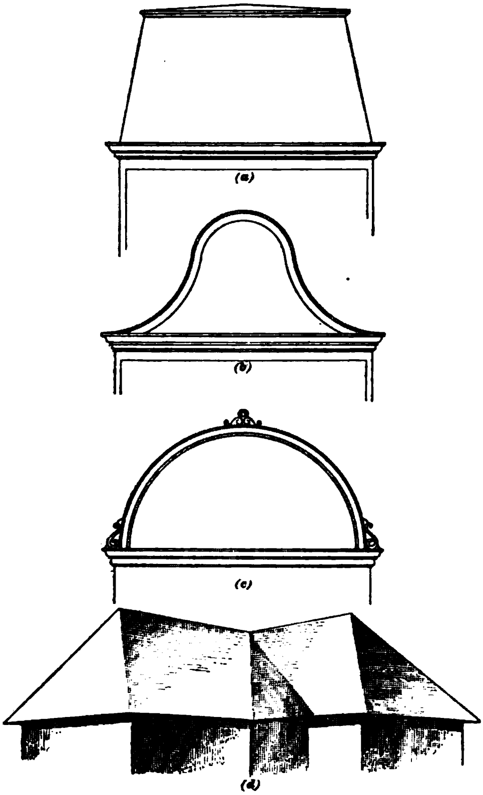


Fig. 11

In Fig. 10 (*a*) is shown a *pent*, *shed*, or *lean-to roof;* in (*b*), a *gable roof;* in (*c*), a *hip roof;* and in (*d*), a *curb*, or *gambrel*, *roof*.

In Fig. 11 (*a*) is shown a *Mansard roof* with deck, or flat, top; in (*b*), an *ogee roof;* in (*c*), a *semicircular*, or *barrel*, *roof;* and in (*d*), a *hip-and-valley roof*.

In Fig. 12 (*a*) is shown a *dormer-window*, with cheeks, or flanks; in (*b*), an *eyebrow window;* in (*c*), a *squint* with cheeks, or *flanks;* and in (*d*), a *louvre ventilator.*

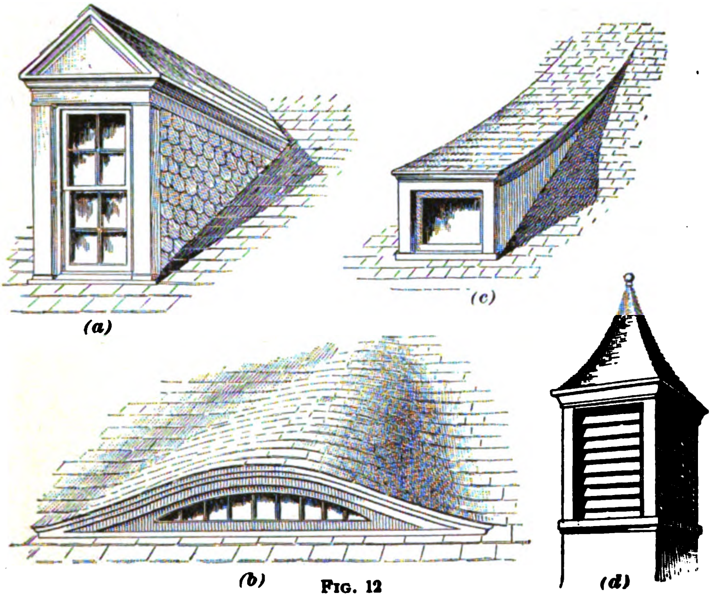


FIG. 12

The pitches are regulated by a recognized standard of the style to which they belong. Thus, in Fig. 13 (*a*) is seen the pitch generally found in Grecian design, that is, inclined from 12° to 16°; in (*b*) the inclination is from 23° to 24°, which was the rule in Roman design; in (*c*) is shown the Gothic, or *equilateral*, pitch; and in (*d*), the Elizabethan, or *knife-edge*, pitch.

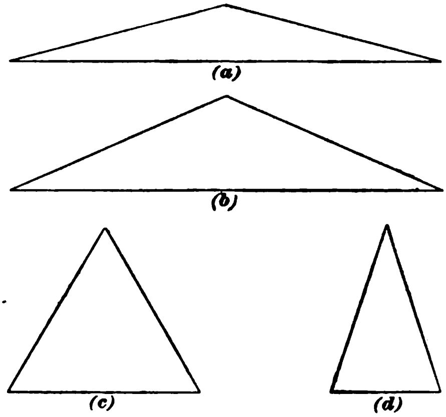


FIG. 13

10. A **dome**, properly speaking, is a spherical form of roof; the term, however, is now applied to various forms having a circular base. Thus, in Fig. 14 (*a*) is a *surmounted dome;* in (*b*), a *semicircular dome;* in (*c*), an *ellipsoidal dome;* in (*d*), a *segmental dome;* and in (*e*), a *bell dome.* There are many other varieties, known as Turkish, Saracenic, Russian, etc.

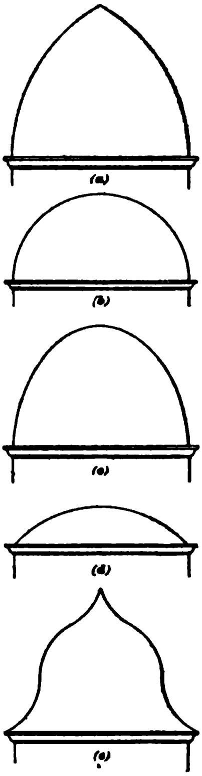


FIG. 14

PARTS OF A ROOF

11. The following terms are applied to express the different elements, or details, that exist in nearly all roofs:

Span is the distance between the supports.

Rise is the vertical distance between the ends of a slope.

Run is the horizontal distance between the ends of a slope.

Pitch is the slope of the rafters as determined by both the rise and the run.

The **eave** is the lower part of the roof projecting over the wall.

A **gable** is that portion of a wall extending above the eaves; it is generally built to the shape of the roof abutting or covering it.

Hips are the salient angles formed by the intersection of the roof slopes.

Valleys are the reentrant angles formed by the intersections of the slopes. A *close valley* is that in which the material used in covering the roof is mitered and flashed at each course, no metal being exposed. *Open valleys* are formed by sheets of metal laid with a portion of their sides under the material used in covering the roof, and with the center part, or valley gutter, left exposed for a width of 4 or 5 inches on each slope.

The **ridge** is the line formed by the meeting of the slopes of the roof at its summit, or apex.

Saddles are small inverted V-shaped pieces of roof, placed at the backs of chimneys or other portions of a building, protruding through and above the roof. They serve the double purpose of shedding water and preventing snow and ice from accumulating.

A **cant** is an angular-shaped piece of roof, used on flat-pitched roofs with parapet walls and placed at the lower end of the roof, commencing at a point at the leader head, and gradually running out on the roof, until, at the opposite end, it is 4 or 5 feet wide and extends upwards on the wall about a foot. It is also used back of bulkheads, etc., for the same purposes as the saddle.

A **curb,** or **combing,** is a support for a skylight, or scuttle, and surrounds the opening cut in the roof.

A **bulkhead** is formed by a partition built around the openings cut into the roof for elevators, stairways, dumb waiters, and air-shafts. It is also occasionally applied to the vertical or sloped backing in the rear of the main cornice.

A **tilting strip,** or **fillet,** is a triangular strip of wood used to raise the flashing, shingles, slate, tile, etc. at the eaves, gable ends, around chimneys, skylights, bulkheads, and ventilators, or against parapet and gable walls, to prevent the accumulation of dust, water, or snow.

DESIGN AND CONSTRUCTION OF ROOFS

GENERAL CONSIDERATIONS

12. In planning a roof, the first thought should be given to the pitch, which depends on the climate, against which the roof is to act as a protection; the second consideration is the devices of construction to aid the free flow of water from the whole external surface when covered; and the third is the determination of the materials best suited to both the pitch and climate.

13. Comparative Pitches.—Fig. 15 is a diagram giving the comparative pitch of roofs, from $\frac{1}{6}$ to $\frac{1}{2}$ pitch, and Table I gives a list of roofing materials and the minimum pitch permissible with each.

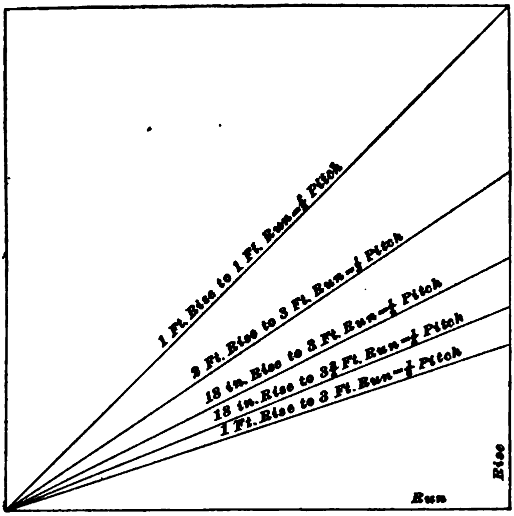

1 Ft. Rise to 1 Ft. Run=½ Pitch
2 Ft. Rise to 3 Ft. Run=⅓ Pitch
18 in. Rise to 3 Ft. Run=¼ Pitch
18 in. Rise to 3¾ Ft. Run=⅕ Pitch
1 Ft. Rise to 3 Ft. Run=⅙ Pitch
Rise
Run

FIG. 15

TABLE I

PITCH OF ROOF ALLOWED FOR VARIOUS MATERIALS

Material	Pitch Inches to the Foot
Asphalt and composition	½
Tin	⅜
Zinc	⅜
Corrugated iron	3
Sheet iron	3
Copper	½
Lead	⅜
Thatch	6
Shingles	4
Slate	4
Tiles, terra cotta or copper	4

14. Although there are no invariable rules governing the pitch of roofs, it has been the custom to construct slopes suited to different localities, and to use the materials that are best adapted to meet the climatic changes.

In hot countries, the lack of rain makes it unnecessary to give the roof more pitch than enough to shed the water; but the roof must be well constructed and tight, for when rain falls in hot regions it does so in large volume. Rapid evaporation is a great help in preserving the roof, for when the rain ceases the roof is soon dried, and the conditions tending toward corrosion or decay of the materials are removed.

In cold climates, where the air holds moisture, and rain and snow are driven by high winds, the pitch must be steep, to prevent the loosening of shingles, slates, or tile by the wind, and to cause snow and moisture to be quickly shed from the roof.

In temperate climates, the pitch may be varied as the locality approaches either the warm or the cold zones.

In very wet, damp, or cold situations, the roof is frequently given a pitch of from 40° to 60°; in dry climates, where the roof is quickly cleaned of water, a moderate pitch of from 20° to 30°; and in hot climates, only sufficient to shed water. This must, of course, be varied with the material used. Thus, shingles, slate, or tiles could not be used in a hot climate, unless the pitch were sufficient to keep water from driving under them, or overflowing their edges during a rainfall. Neither could lead be used on a steep-pitched roof, as it would crawl off by expansion.

15. Precautions at Angles and Intersections.—The roof should be carefully prepared for the covering, and all pockets, where ice, snow, or water can accumulate, must be avoided in the construction. On steep roofs, the backs of chimneys or other vertical walls cutting the roof plane must be fitted with a saddle or cant board. All angles made by corners or flashings against walls should be avoided, and a tilt fillet or cant board should be used, to allow the flashing to take an easy bend. In slate, shingle, and tile roofs, this observance will assist the passage of water and snow and prevent its accumulation. On metal roofs, sand, dust, or other refuse blown thereon will not lodge very readily. Where such accumulations do lodge on the roof, they keep it damp, rotting and corroding the most vulnerable parts.

16. The **roof boarding** should run one way, so that the shrinkage may be uniform and not pull and tear the joints of the roofing material. With metal roofs, it is best to have the boards laid from the eaves to the ridge, as this, in case the boards warp, brings the ridges thus raised in the roof in line with the current or pitches. This is not always practicable, but in any case it is possible to lay the boards diagonally. The nails driven from the surface of the roof should be countersunk at least $\frac{1}{4}$ inch below the top surface of the boards, to prevent corrosion and wear of the covering.

17. Double gables, or dormers, in which the roofs form an ⋀⋀ should not be erected, it being almost impossible to keep them clear of snow and ice in winter; for the same reason, decks should not be used, unless unavoidable.

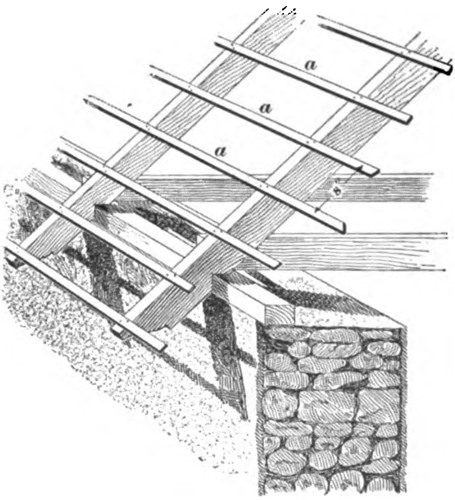


Fig. 16

THATCH ROOFING

18. Thatching on a house is an admirable covering for securing warmth in winter and coolness in summer, but, being subject to injury from birds and a great risk from fire, it is very seldom used. A good thatch roof has been known, when well put on and composed of sound straw, to last from 10 to 14 years; while in respect to its being the most picturesque form of covering for cottages, arbors, and like buildings, there can be no room for question.

19. The roof is prepared to receive the thatching by nailing to the rafters, lath, or light purlins, at 8-inch centers, as shown at *a*, *a*, Fig. 16, on which the straw is laid. Like slating or shingling, the thatching is commenced at the eaves by laying on bundles, about 3 or 4 inches in thickness, and securing them to the laths, using a thatcher's needle and rope yarn. The yarn is tied around the purlins, as shown at *a*, *a*, Fig. 17, or hung with thatching hooks, which are tied to the head of each bundle and hooked over the purlins. Starting at the end wall, or at the gables, full-width bundles are laid until a row reaches the ridge, the thickness of the completed row being from 12 to 15 inches.

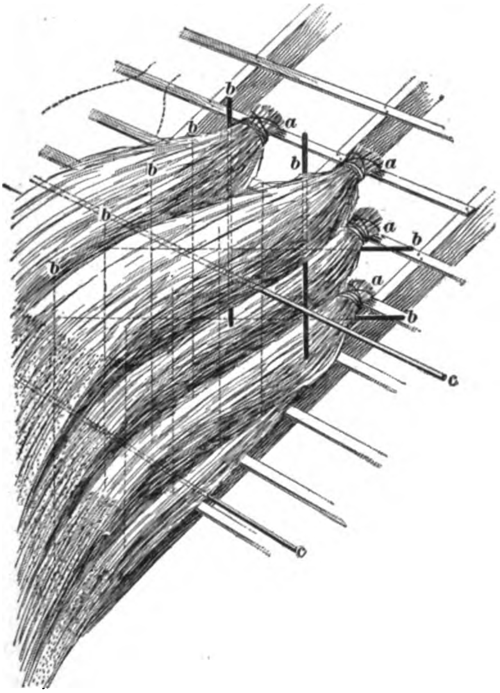


FIG. 17

After two or three rows have been put on, they are interlaced with *withes*, or *reeds*, as shown at *b*, Fig. 17, the ends of the withes being bound together and nailed to the purlins; the withes may also be tied to the purlins with the yarn.

The rods *c*, *c* are run through the thatch after 8 or 10 feet has been laid. These rods are spaced about 2 feet apart, and are secured by looping a withe over the rods and nailing the ends to the rafter.

Where the thatch comes against the gable wall, the joint should be well filled with lime mortar. After allowing this to thoroughly settle, it is pointed with cement mortar, carried well up against the wall. Similar pointing should be used about chimneys or other openings, or a canvas flashing may be nailed to the walls with a wood strip at the top, the flap being turned out on the thatch and the whole thoroughly tarred.

The ridge may be formed of thin bundles of straw, laid with the middle on the ridge and afterwards withed down to the roof, as in Fig. 18 (*a*); or the straw ends of the upper layer may be turned up and withed together and surmounted by a terra-cotta ridge cresting set in cement, as shown in Fig. 18 (*b*).

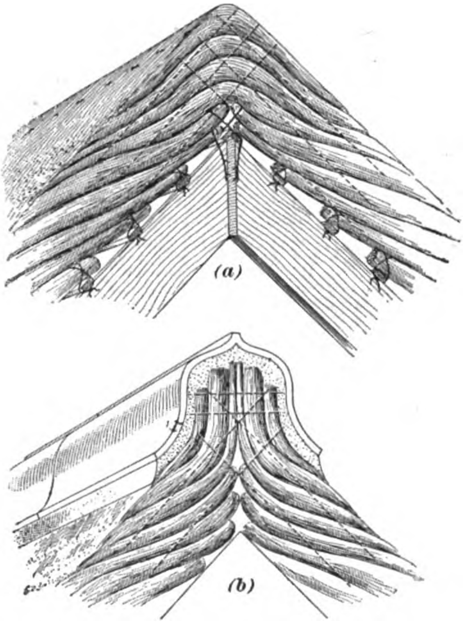


FIG. 18

The eaves may be raked out until the edge is very fine, thus forming a round, easy shed for the water, as shown in Fig. 19 (*a*), or cut off on the under side, as shown in

Fig. 19 (*b*). As each course is laid, the lap ends should be raked out, to maintain as even and continuous a surface in the finish as possible.

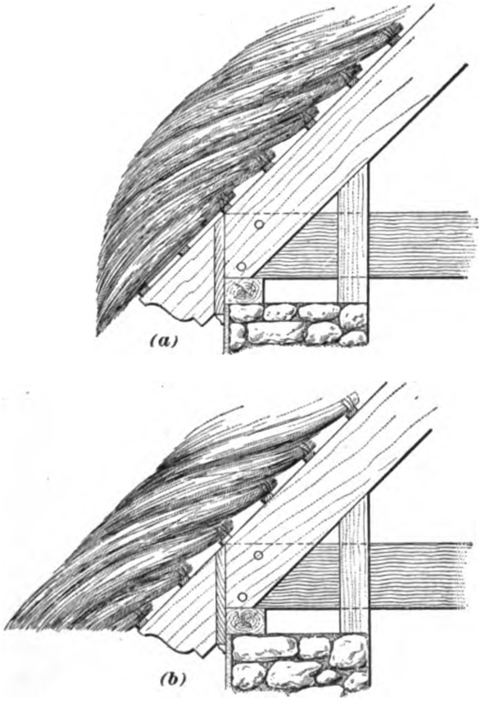


Fig. 19

20. Implements and Materials for Thatching.—The thatcher requires the following: A common stable fork, to toss the straw together before it is made into bundles; a thatcher's fork, to carry the straw up to the roof; a thatcher's rake, to comb the straw straight and smooth; a knife, to point the withes; a half glove of leather, to protect the hand when drawing or pushing in the smaller withes; a long, flat needle; and a pair of leather gaiters, to come above the knees, for protection when kneeling on the rafters.

The materials required are good straw of any kind, or straw reeds, wheat straw being the best; also rope, nails, withes, and rods.

To complete a square of roof, that is, 100 square feet, the materials necessary are: About 650 pounds of straw, to be laid on from about 12 to 14 inches thick; one bundle of oak laths, to be nailed to the rafters, the lath being 1¼ inches wide and from ½ to ¾ inch thick; 75 withes; 1½ pounds of rope yarn, or, in its place, Manila rope; 35 rods; and 250 nails.

ASPHALT ROOFING

21. Asphalt, or solid bitumen, is a natural mineral product and is found in several countries, but principally in the great pitch lakes of Trinidad, an island in the British West Indies. Asphalt, combined with calcareous earth, that is, earth containing lime, forms a compact, semielastic solid, that is not liable to injury from the strongest influences of cold or heat, impervious to water, and unaffected by acids.

22. Methods of Laying Asphalt.—There are three methods of laying asphalt for roofing purposes: The first and most durable method consists in laying felt that is free from asphalt, then applying a coat of hot asphalt, and finishing with a covering of gravel. The second method consists in laying sheets of felt saturated with asphalt and finishing with sand. The third is similar to the first, except that the finishing is done with a coating of Portland cement.

23. Laying the Roof.—The application of the covering is the same in each case, except that the first and third methods require copper or lead flashings. In laying the roofing, two thicknesses of composite roofing felt are laid from eaves to the ridge, the Manila side of the felt being placed downwards, lapping each sheet about 17 inches over the preceding one, the felt being secured with nails through tin disks about 2½ feet apart. The entire surface should then receive a coating of natural asphalt cement.

Another thickness of the felt should be laid in the cement, lapping each successive sheet about 2 inches over that preceding it, cementing the edge thoroughly with hot asphalt, and securing it with nails through tin disks. Over the entire surface of the felt thus laid, there should be spread an even and continuous coating of the cement. Over this, another thickness of felt is laid, having the lap come in the middle of the first sheet of the felt beneath, lapping the edges and securing with cement and nails as before. The final coat of cement is then applied, and this coating should immediately be covered with an adequate body of well-screened gravel free from dust.

In cold weather, the gravel should be heated. The only difference between a gravel roof and an asphalt roof is that in the former coal tar is used instead of asphalt.

Slag roofing is laid much in the same way, except that tar and crushed slag is used instead of asphalt and gravel.

24. The **flashing** for asphalt roofing should preferably be of copper, as should also the eave stops and nails. Flashings of zinc, galvanized iron, or tin may, however, be used as fairly satisfactory substitutes for copper.

The **eave stops,** shown at *a*, Fig. 20, should extend not less than 2 inches on the roof, as shown at *b*; they are laid over the felt and extend downwards over the eaves about ½ inch below the under surface of the roof boards, as shown at *c*.

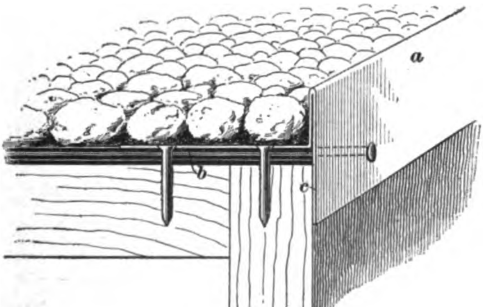


Fig. 20

The *wall* flashings, shown at *a*, Fig. 21, should extend at least 2 inches over the felt on the roof. They should be well nailed, and should be covered with asphalt cement before the gravel is applied. The flashing should project upwards against the wall at least 5 inches and be secured with flashing hooks, and should have the vertical joints *c* locked and soldered.

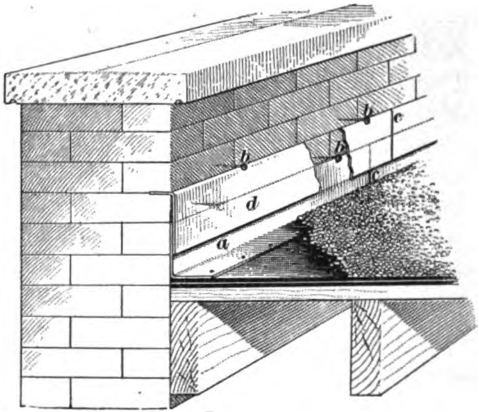


FIG. 21

The flashing should be covered with a *counterflashing* *d*, which reaches within 2 inches of the roof. The top edge of the flashing is turned into the wall not less than 1¼ inches and is secured by wall hooks, as shown at *b*, the joint being filled with elastic cement.

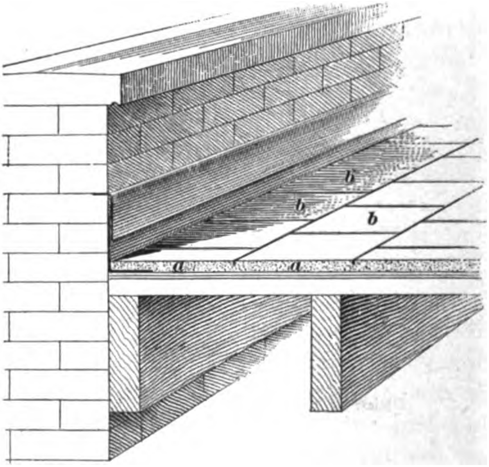


FIG. 22

This roofing may be covered with a layer of hydraulic cement, as shown at *a*, Fig. 22, in the place of gravel. The cement should be about 1½ inches thick and divided into small sections *b*, *b* suggestive of stone or tile.

The outside angles of walls and chimneys should be flashed, as shown in Fig. 23. A strip of felt 8 inches wide folded and cut as shown at *a*, is bent around the angle and nailed and cemented, with the liquid coating, over the under roofing *b*, after which it is counterflashed, as shown at *c*.

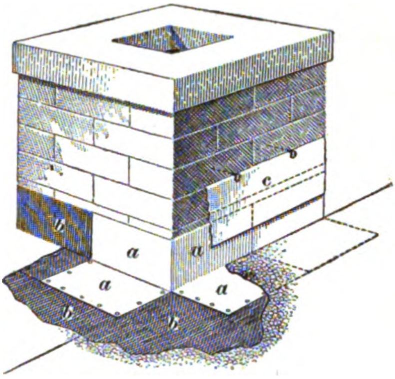


Fig. 23

The inside angles of walls should be flashed, as shown in Fig. 24, the strip of felt *a* being of the same dimensions and similar to that used for outside angles; the process of applying is the same.

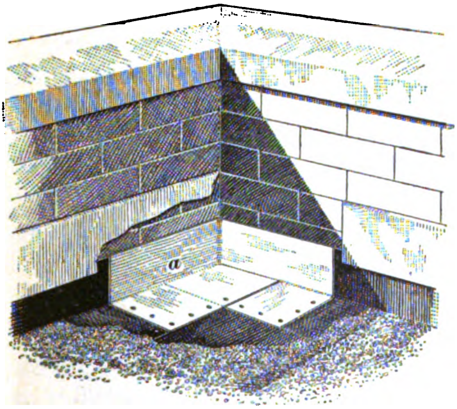


Fig. 24

The ridge should be capped with a 16-inch strip of felt, lapping 8 inches on the roof each side of the ridge, well cemented and securely nailed at the edges and joints. The best temperature in which to apply the roofing is about 35° F. If colder, the material should be kept in a warm room and taken out only as required. The quantity of material required to lay and cover a square of this roofing is: 1 roll of two- or three-ply natural asphalt roofing; 2 gallons of liquid coating; 1 pound of nails; and 1 pound of tin disks.

ASBESTOS ROOFING

25. **Asbestos** is a white, gray, or green-gray fibrous mineral. The fibers are sometimes very long, easily separable, and flax like, sometimes compact and capable of a high polish. Asbestos is very soft when reduced to powder, is incombustible, and from white, green, and gray turns to red and black. It is mined in Canada, Vermont, Virginia, South Carolina, and Staten Island, New York.

Asbestos for roofing purposes is usually made in rolls, though some firms are now manufacturing asbestos shingles. These asbestos shingles are very hard and are laid in the same manner as wooden shingles.

26. **Laying Asbestos Roofing.**—Before applying asbestos, the roof surface should be cleaned of all refuse; care should also be taken that the joints of the boards are planed to a level surface and then thoroughly swept.

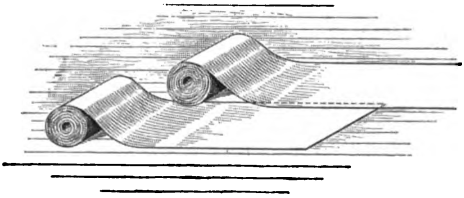


FIG. 25

Unroll the roofing as shown in Fig. 25, taking care that the material passes over and not under the roll, otherwise the sheets will be laid wrong, it being necessary to have the coated side up to properly shed the water. Cut enough off the roll to cover the length required. Commencing at the eaves, lay the sheets in succession parallel to the eaves. The lap for steep roofs should be 1½ inches, and for comparatively flat roofs, 2 or more inches. Where short lengths are used, see that vertical joints do not come in line with each other; and on steep roofs, where the roofing is vertical, or from ridge to eaves, place a continuous strip next to the short lengths. All edges and laps are to be cemented before being nailed down, and the nails should be spaced 1 inch apart. When the roofing has been nailed, cement a second time, thoroughly covering the joints and laps, concealing all nail heads and filling up the edges as much as possible. Next apply a coating to the entire surface of the roof, and when thoroughly dry, apply a second coating, finishing, while fresh, with an even covering of finely ground asbestos powder.

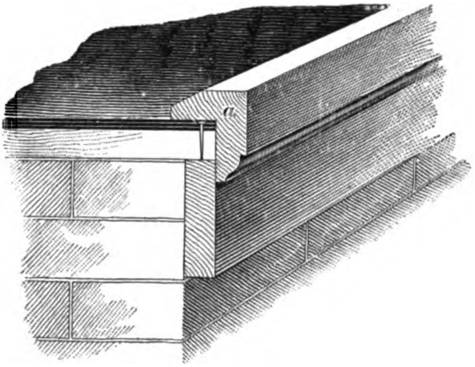


FIG. 26

Where there are no gable walls, the roofing should be thoroughly cemented at the edge of the roof with a coating mixed and thickened with hydraulic cement. It should, also, be nailed down close and tight and then covered with a wooden cap molding *a*, as shown in Fig. 26.

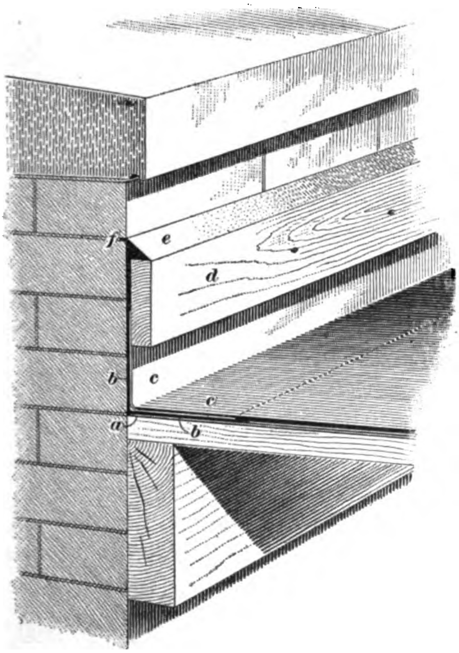


FIG. 27

27. In cases where there are parapet walls, chimneys, bulkheads, etc., the roofing should run to the angle only, as shown at *a*, Fig. 27. When the roofing has been nailed in place, the angle formed by the roof and walls should be thoroughly cemented. While this coating of cement *b* is wet, apply a separate flashing *c*, as shown; this flashing should be 8 inches wide, 4 inches on the roof and 4 inches up against the walls, nailed and also cemented.

Where a metal counterflashing is used, the upper edge of the flashing should be secured as shown at *b*, Fig. 21, or a wooden strip *d*, well nailed to the walls, may be used, finishing the top with a good coating of cement *e*. By using a wide strip of wood, and keeping the top of it flush with a joint *f* in the brickwork, the mortar can be raked out from between the bricks and a coating of cement made to enter the joint, thus rendering it more secure and water-tight.

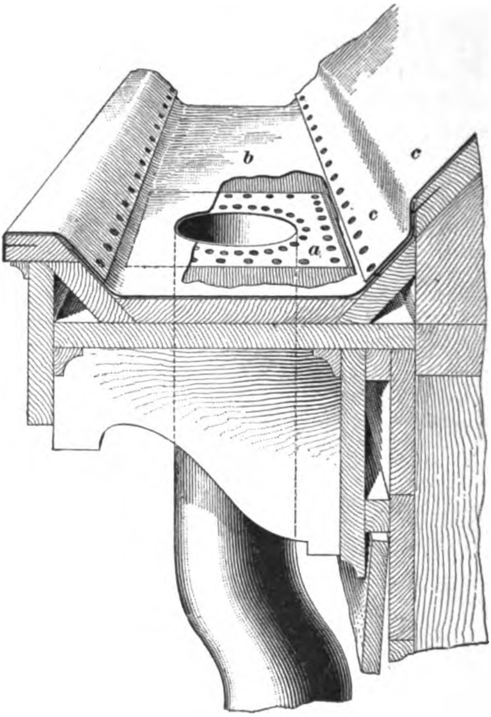


FIG. 28

In using tin, copper, or zinc for counterflashings around the corners of chimneys, etc., the metal should be cut and formed as shown in Figs. 23 and 24, and carefully cemented and nailed in place. Where the roofing connects with tin, or some other metal portion of the building projecting through the roof, the edges should be carefully secured by nailing and cementing.

28. At the gutter outlet, a metal tube of sufficient length to extend through the cornice about 1½ inches, and just small enough to slip tightly inside the leader, is soldered to a sheet of metal about 10 inches square, through which a hole the size of the outlet has been cut. The tube is then placed in position and thoroughly cemented and nailed, as shown at *a*, Fig. 28. If the gutters are to be lined with roofing felt, a separate strip *b* should be laid in the trough before applying the material *c* on the roof proper. Then nail and cement all the edges and laps, and give them an extra coat of cement. Care should be taken to avoid forming sharp angles in the roofing felt and injuring the material while applying it to the roof.

29. All laps should be made with the current, or pitch, of the roof. Large roofs should have a pitch of not less than 1 inch to the foot, and the roofing should not be applied when the temperature is below 40° F.

The materials required to cover 100 square feet of roof surface are as follows: ½ roll of asbestos roofing material, 1½ gallons of coating, and 1½ pounds of nails.

WOODEN-SHINGLE ROOFING

30. **Wooden shingles** are made by sawing or splitting chestnut, hemlock, cedar, white pine, cypress, or redwood.

Chestnut shingles are apt to curl in dry weather, and when damp they swell and bulge; this continued movement gradually draws the nails and cracks the shingles.

Hemlock shingles are more serviceable than is generally supposed, and last a long time in dry localities; but in a moist atmosphere they decay quickly.

Red-cedar shingles are very durable, and for this reason are largely used. Because of the general straightness of the grain, red-cedar shingles are not roughened so much under the sun as are other kinds, and therefore give a better weather surface.

White-pine shingles are commonly used, because, while offering more advantages under general requirements, they last longer than any but cypress, white cedar, or redwood, and do not curl and split so readily as the foregoing kinds. Their chief disadvantage is in the sawing, as the fiber roughens quite freely.

Cypress and *white-cedar shingles* are the least used, and, at the same time, about the best that can be had. The wood saws fully as well as red cedar, and will not curl or split, except under excessively severe conditions; with the exception of redwood, the enduring qualities of these shingles are far superior to any other shingles known.

California redwood makes a good durable shingle that is not as inflammable as cedar and other shingles. The wood is soft and seems to resist the tendency to rot for many years. Roofs built in such a climate as that of Boston, Massachusetts, have even outlasted those built from the best white cedar.

31. Sizes and Terms.—The ordinary lengths of shingles are from 16 to 18 inches, or from 24 to 27 inches, and the widths, from 3 to 7 or 10 inches. A bundle contains about 250 shingles. Thick shingles measure about $\frac{9}{16}$ inch, and thin ones about $\frac{3}{8}$ inch, at the butt. Shingles are wedge-shaped and $\frac{1}{16}$ inch thick at the upper end.

Dimension shingles are always cut to a uniform size or width, and are preferable in laying patterns; they are 4, 5, or 6 inches in width, and are usually dressed. The term *No. 1* signifies that the entire shingle is of a clear, sound, serviceable wood, free from all knots, sap, etc.

Shaved shingles are split and shaved with the drawing knife.

Clear butts indicates that the shingles contained in the bundle have a clear butt, or enough clear surface for exposure to the weather.

Fancy butts, or **pattern butts,** are shingles having the butts, or ends, sawed to a geometric or other form, such as saw tooth, round, hexagonal, etc. These shingles are usually dressed.

Shingle lath, on which the shingles are laid, usually runs from 1¼ in. × 2 in. to 1¼ in. × 3 in.

Valley, hip, and **ridge boards** are either 1 inch or 1¼ inches in thickness, as required.

LAYING SHINGLES

32. The methods of laying shingles generally in use are: (1) on shingle lath; (2) on boarding without paper or felt; and (3) on matched boarding and lath with felt.

The first method is undoubtedly the best, though it is generally used only on cheap buildings. In more expensive houses, the requirements usually call for a matched-board roof. This method, however, prevents the free circulation of air under the shingles and causes them to decay quite rapidly.

33. First Method.—To lay shingles according to the first method, there should be from one to three roof boards, about 10 inches in width, laid along the eaves to receive a few of the first courses of shingles. The object of placing these boards in this manner is to protect the shingles should it become necessary to walk along the eaves to make repairs. If the valleys formed by the main roof and dormers are not very long, one board on each side is sufficient. These boards also act as a stop to the wind, and, to a great extent, prevent rain from being blown over the flashing. The same remark applies to hips and ridges.

The starting course of the shingles should be doubled at the eaves, and the ends should overlap the gutter about 1½ inches.

Each shingle is fastened with two fourpenny nails, at a distance of about 2 inches above the upper line of the exposure. The amount of exposure or gauge is measured back from the butt ends of the shingles, and a mark is struck with a chalk line, to which mark the butts of the next course of shingles are laid. The heads of the nails are in this manner protected by the laps, and the shingles are further secured by the nails of each succeeding course passing through the heads of the previous course. If the gutter is built on the surface of the roof, as shown in Fig. 31, the butts of the shingles should be placed well up above the overflow line.

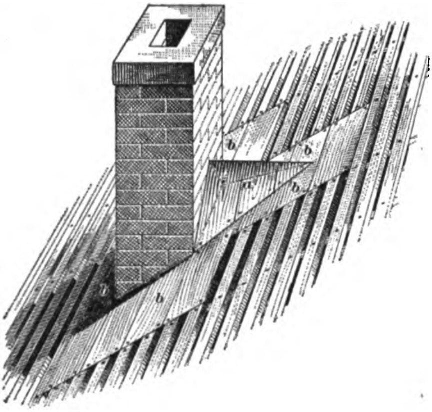


FIG. 29

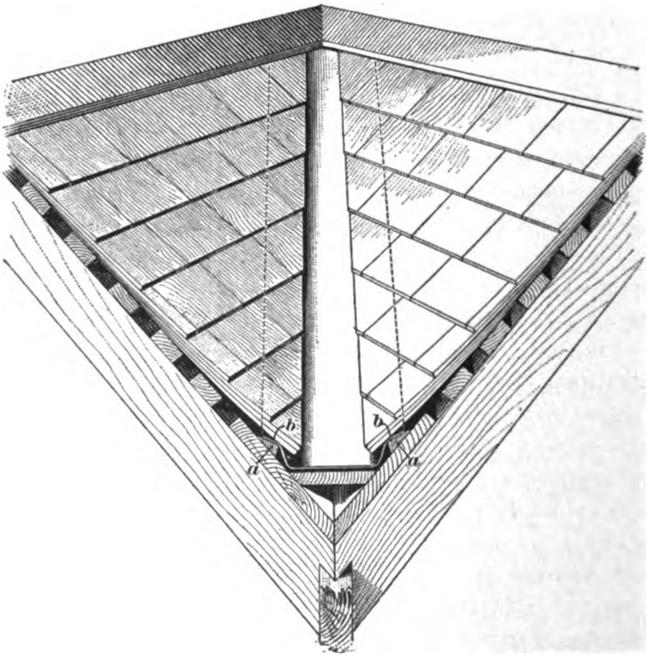


FIG. 30

34. Around all chimneys, ventilators, skylights, etc., the roof should be boarded to the first rafter on each side; and at the back of all chimneys, a saddle should be built as shown at *a*, Fig. 29; then nail the boards *b*, *b* at each side and at the front.

Along the valleys should be placed tilting fillets *a*, *a*, Fig. 30, over which the flashing is formed. Similar tilting fillets should be placed along the upper edge of the gutter, just above the overflow.

Gutter linings may with advantage extend several inches up under the shingles, as shown at *b*, Fig. 31. The valley lining should also extend under the shingles 3 or 4 inches, as shown at *b*, Fig. 30; likewise, the chimney flashing should extend 3 or 4 inches at the back and sides of the chimney, and 5 or 6 inches at the front.

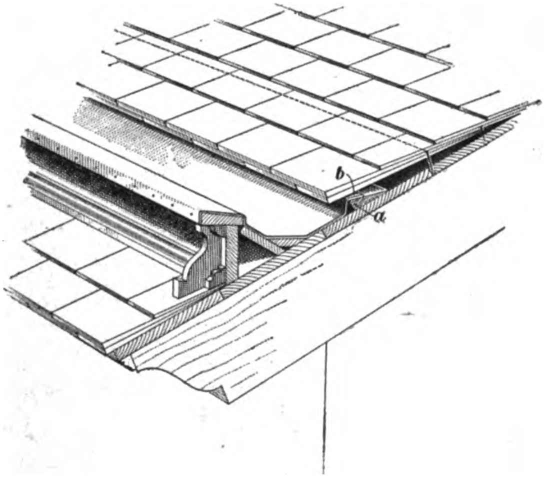


Fig. 31

35. In finishing against *open* valleys, care should be taken to cut the shingles parallel to the line of the tilting fillet, or the result will be a wavy line.

In constructing *close* valleys, the shingles are interwoven with metal sheets, as shown at *a*, Fig. 32, and are mitered in the angle. The shape of these sheet flashings will vary with

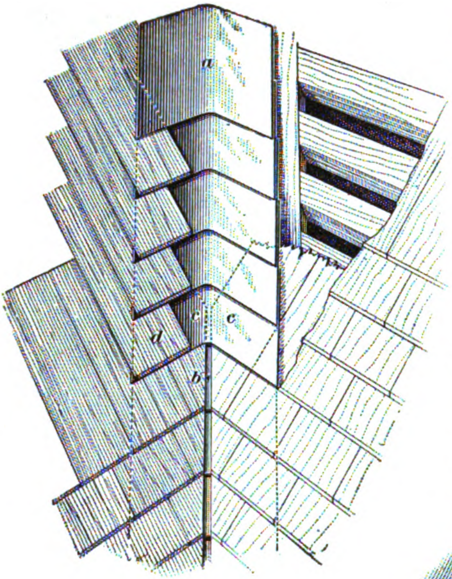


FIG. 32

the pitch of the roof, if it is desired to make the lower edges of the sheets parallel with the butts; but this is not necessary, as square sheets will serve the same purpose, provided they are properly lapped.

The general manner of constructing this valley is as follows: A row of shingles is laid each side of the valley, a clear space of ½ inch being kept between the miter edges, as shown at *b*, to allow for expansion. The gauge is then measured, and the flashing set, as shown at *c*, *c*, to the line so obtained; the next course of shingles, as shown at *d*, covers the metal entirely, and each ascending flashing will be covered in a like manner. This gives a tight valley and is used more on account of appearance than durability; for snow and rain are likely to keep the

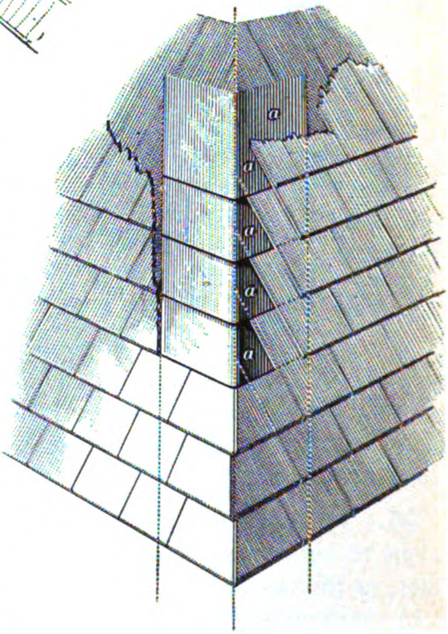


FIG. 33

shingles damp, and thus cause them to rot before the rest of the roof.

36. The method just described as applied to the hips of roofs is shown in Fig. 33, *a*, *a* being the flashing laid in with the shingles. While the life of the shingles is not thereby prolonged, still this method makes the most weather-proof hip possible, outside of a metal roll, which on account of its poor appearance should be avoided.

37. The method known as the **Boston hip** is very effective and neat, and under ordinary conditions, especially on a very steep roof, is sufficiently weather-tight for all purposes.

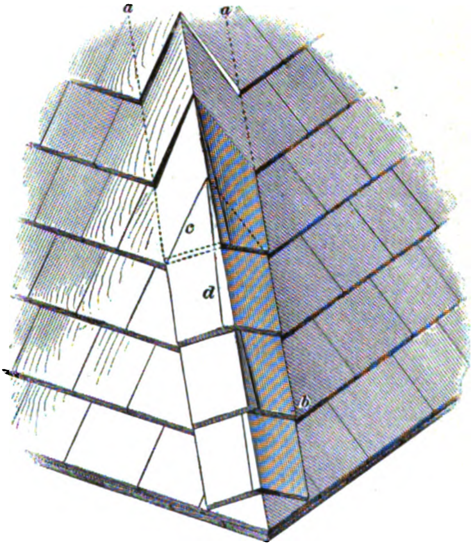


FIG. 34

Shingles of a uniform width of, say, 5 inches, should be selected. A chalk line is snapped on each side of the hip, about 4½ inches from its center and parallel to it, as shown at *a*, *a*, in Fig. 34. The slope shingles on the main roof should be carried up to this line, stepping back to allow the hips to be laid last. Lay the bottom shingles first with their edges at, and parallel to, the hip line, and the lower corners of their butts just touching the butts of the shingles below, as shown. Across each hip shingle, and at right angles to the eaves, draw a line for the vertical side cut, as at *c*. Slightly taper the side *d* to secure a close fit at the intersection. Fit the hip shingle to the side of the main roof shingle, and nail in place as shown.

One of the chief advantages of this method is that the grain of the wood runs with the hip, and the tendency to curl is taken away from the line of the hip to the side of the shingle.

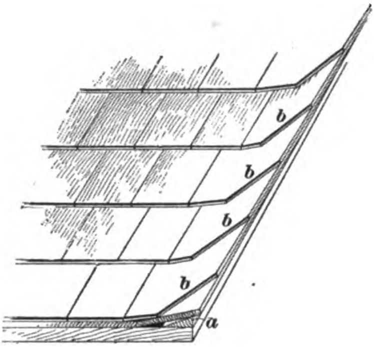


FIG. 35.

The appearance of the roof may be improved, and the drip over the gables may be stopped, by putting a tilting fillet up the rake, running the shingles up on it, as at *a*, Fig. 35, and cutting the ends of the shingles at an angle of 45° to the side joint, as shown at *b*.

38. There are three methods of finishing the ridge of the roof. The first consists in laying over the last row of shingles but one, a metal flashing, as at *a*, Fig. 36, which extends on each side of the ridge to the depth of the last row, after which the last row of shingles *b* may be laid and the ridge capped with a ridge saddle of white pine $1\frac{1}{4}$ inches thick. The first side *c* is put on flush with the ridge and the finished piece is put on with a lap of about $\frac{1}{2}$ or $\frac{3}{4}$ inch, as shown at *d*.

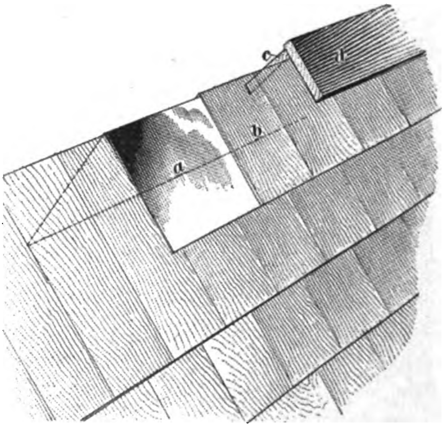


FIG. 36

The second method, shown in Fig. 37 (*a*), consists in taking two ridge pieces *a*, *a*—one of them the thickness of a board wider than the other—and laying them over two other pieces, which are just the thickness of the shingles. These latter pieces are nailed to the roof boards and abut against the shingles. The top of the ridge piece is capped with a wooden roll *b*. No metal flashing is required, as the roll effectually covers the joint.

The third method is shown in Fig. 37 (*b*) and is similar to the second, except that the wooden roll is covered with a galvanized-iron or copper roll *c* and wings pushed over it. Galvanized nails are driven into the roll, near the wings, to keep it in place; lead may also be used for the same purpose.

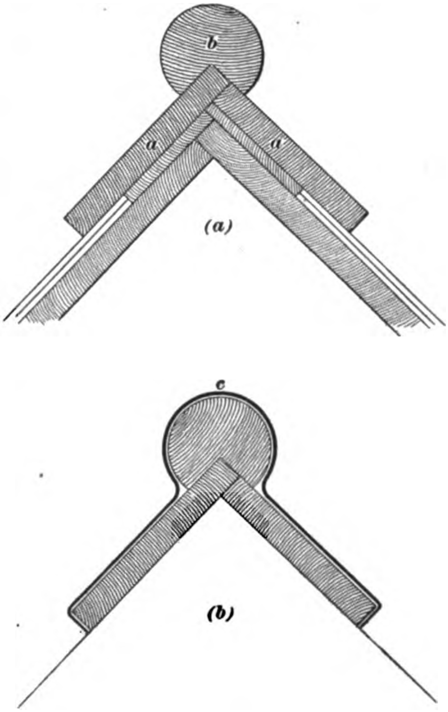


FIG. 37

39. Second Method. The second method of laying shingles is that of laying them on boards that cover the entire surface of the roof. The boards should not be set close together, as they would then prevent the passage of air, stop ventilation, and cause the shingles to decay. This process of decay arises from the warm air of the rooms below condensing when it comes in contact with the roof, making the material wet, or resulting in what is called *sweating*. It is also caused by capillary attraction acting through the butt ends of the shingles.

40. Third Method.—The third method of laying shingles, shown in Fig. 38, is on matched boarding *a*, *a* covered with roofing felt *b*, *b*; the lath *c*, *c* is then nailed on, the same as in the first method, and the shingles are laid on the lath.

This method makes a very good roof when the spaces between the ends of the lath are left open at the gables for ventilation; but when these spaces are closed, as is usually the case, it makes the poorest roof of all, as the closed air space only increases condensation and hastens the destruction of the roof.

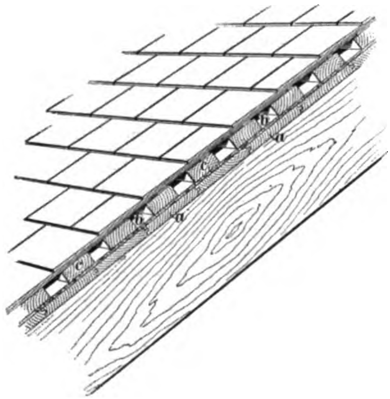


FIG. 38

41. In laying shingles on a roof, the best results are obtained and their endurance, which is the chief point, is vastly increased by setting the shingles from $\frac{3}{16}$ to $\frac{1}{2}$ inch apart. This allows the water to drain off rapidly, dries the roof quickly, and also allows for expansion and prevents buckling. Where narrow shingles are used, the joints should not be less than $\frac{1}{8}$ inch; while for shingles over 5 inches in width, from $\frac{1}{4}$- to $\frac{1}{2}$-inch joints should be allowed.

42. Shingling Conical Roof.—For covering conical roofs, the shingles should be selected in three or four widths, the largest butts being 5 inches at the gutter, and the smallest, 2 inches at the top, as shown at *a*, *b*, *c*, *d*, Fig. 39.

To keep the shingles true to the radial lines, and the butts in line with the horizontal curves or courses running around the tower, a nail is driven into the center of the apex post *e*, to which a cord is attached. The starting course is laid horizontal with the eaves, the next gauge is laid off, and a shingle *g* is tacked in place. The cord is held to a joint of the first course under the tacked shingle, and a line is drawn through the center of the shingle *g* vertically; the cord is then moved to the outside corner of the butt, first on one side *h*, and then on the other side *i*. The side or taper lines *h j* and *i k* drawn in this manner will be radial to the center of the apex, as shown by the plan *l*. A shingle, cut to the lines marked, will form a templet for the first course. The shingles with 5-inch butts should be laid first, then the 4-inch, and so on until each lot is used, making a new templet as often as the joints begin to come too close.

This mode of application should be continued until the base of the finial is reached, when, if a wooden cap is to be used, the apex should be flashed with tin. If, however, a sheet-metal finial is required, the flashing may be omitted.

43. Method of Finding the Gauge.—The **gauge,** or exposure to the weather, of a shingle is obtained by subtracting the lap from the length and dividing the difference by 3. Thus, for a shingle 18 inches long, with a 3-inch lap, the exposed length will be 18 inches minus 3 inches, or 15 inches, which, divided by 3, will give 5 inches.

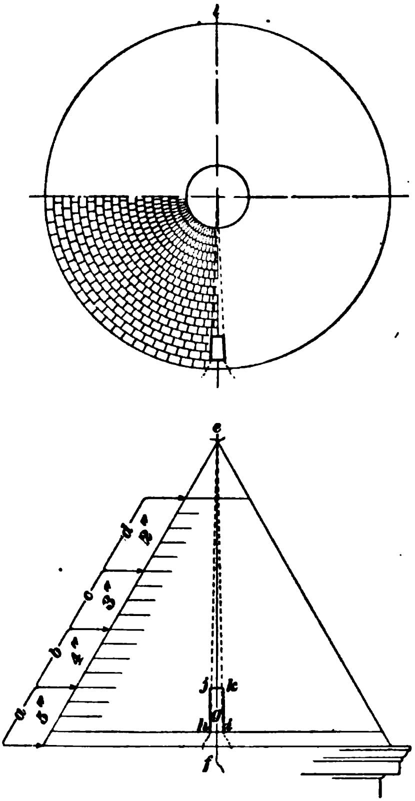


FIG. 39

The number of inches exposed to the weather multiplied by the average width of a shingle gives the area of the exposure; dividing 14,400 (the number of square inches in 100 square feet) by the area of the exposure gives the number of shingles required to cover 100 square feet of roof. For example, the average width of a shingle is 4 inches, and if exposed to the weather 4 inches, the area of exposure is 16 square inches; now, 14,400 square inches divided by 16 gives 900, which is the number of shingles required per square.

44. Number of Shingles Required.—Table II is arranged for shingles from 16 to 27 inches in length, and is based on a given exposure to the weather.

TABLE II

SHINGLES REQUIRED FOR ROOFING

Exposure to the Weather Inches	Number of Square Feet of Roof Covered by 1,000 Shingles		Number of Shingles Required for 100 Square Feet of Roof	
	4 Inches Wide	6 Inches Wide	4 Inches Wide	6 Inches Wide
4	111	167	900	600
5	139	208	720	480
6	167	250	600	400
7	194	291	514	343
8	222	333	450	300

TIN ROOFING

45. General Description.—**Roofing, or terne, plate** is made of soft steel or wrought iron covered with a mixture of lead and tin. Plates in the market are known as *charcoal* and *coke*, the terms being derived from the process of making the iron, and are used for designating the grade of plates when marking the boxes in which the tin is shipped.

Brands are the different marks or devices used by makers. Reliable manufacturers always endeavor to maintain a uniform grade of merit in the different brands they turn out. The best roofing plates always have the brand stamped on each sheet, and it is advisable for architects to specify a brand of tin for roofing that has a reputation for durability.

Gauge denotes the thickness of the plates, and is known by such signs and marks as IC, IX, etc. IC represents a plate in gauge about No. 29, and weighs about 10 ounces to the square foot. IX corresponds to No. 27 gauge, and weighs nearly 12 ounces to the square foot.

Sizes of the plates are marked on the boxes. The common sizes for roofing are: 10 in. × 14 in., 14 in. × 20 in., and 20 in. × 28 in.

A *waster* is an imperfect plate.

Table III gives the size, grade, etc. of tin and terne plate in general use.

TABLE III

	Size Inches	Grade	Number of Sheets in a Box	Pounds in a Box	Gauge
Size and Grade of Tin Plate	14 × 20	IC	112	113	29
	14 × 20	IX	112	143	27
	14 × 20	IXX	112	162	26
	14 × 20	IXXX	112	182	25
	14 × 20	IXXXX	112	202	24
	20 × 28	IC	112	224	29
	20 × 28	IX	112	280	27
	20 × 28	IXX	112	322	26
Size and Grade of Terne Plate	14 × 20	IC	112	112	29
	14 × 20	IX	112	140	27
	20 × 28	IC	112	224	29
	20 × 28	IX	112	280	27

LAYING TIN ROOFS

46. Flat-Seam and Standing-Seam Roofs.—There are two kinds of tin-roof coverings in common use, namely, *flat-seam* and *standing-seam*. In the **flat-seam** method, the sheets of tin are locked into one another at the edges, and nailed to the roof boards, as shown in Fig. 40, using five or six nails to the ordinary 14″ × 20″ sheet. The seams are then flattened down with a wooden mallet and soldered with good half-and-half solder, using

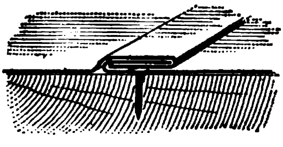


FIG. 40

rosin as a flux. In laying the roof, commence at the eaves, locking the tin into the gutter as shown at *a*, Fig. 41, or into the eave flashing. Fig. 42 shows the method of fastening the sheets with nails driven through the tin; the nails, however, should not be placed over 6 or 7 inches apart, and should be driven well under the seam, as shown in Fig. 40.

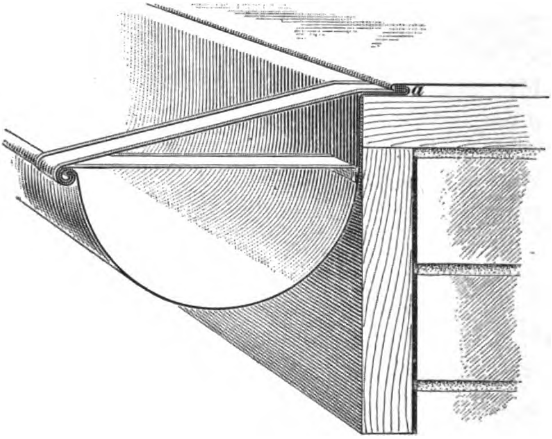


FIG. 41

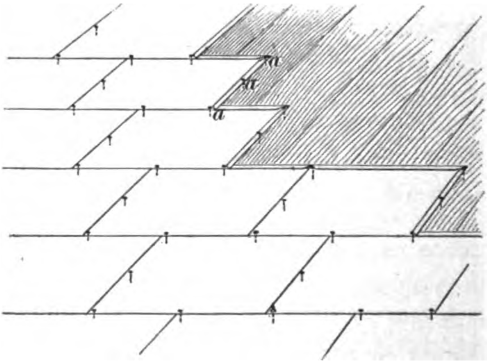


FIG. 42

A better method of fastening the sheets to the roof is by means of tin cleats about 1½ in. × 3 in., as shown at *a*, Fig. 43. The cleats are locked over the upper edge of the sheet *b* and nailed to the roof as shown at *c*. If cleats are used to hold the sheets, when the roof contracts with the cold or expands with the heat, the strain will be on the cleats, and not on the seams, as is the case when the nails are driven through the sheet.

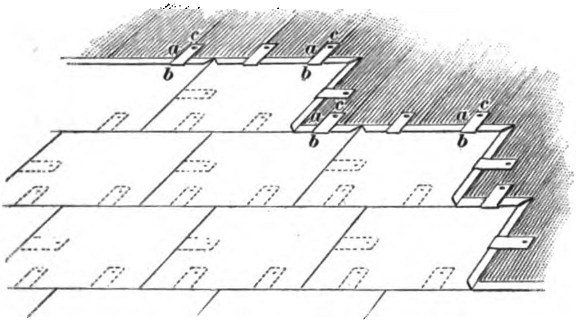


FIG. 43

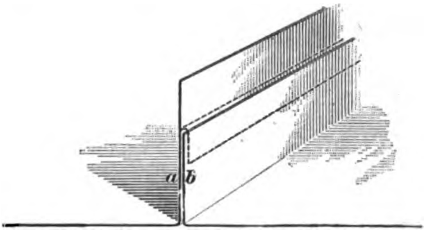


FIG. 44

47. In **standing-seam roofing**, the sloping seams are composed of two upstands. The sheets of tin are first prepared in the shop by locking and soldering them together into long strips that will reach from the eaves to the ridge. Each strip is then placed on the roof, one edge being turned up about $1\frac{1}{4}$ inches and the other about $1\frac{1}{2}$ inches, as shown at *a* and *b*, Fig. 44. These strips are held in place with cleats placed from 12 to 14 inches apart, as at *a*, Fig. 45. After the upstand is double-seamed together and finished, the standing seam is about 1 inch high; the finished seam is shown

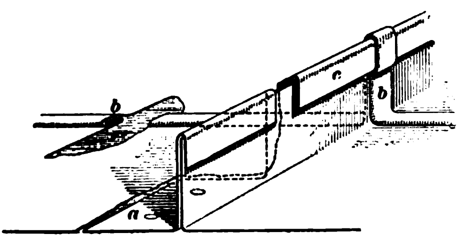


FIG. 45

in Fig. 46. The cross-seams can either be single-locked as in Fig. 47 (*a*), or double-locked as at (*b*); in the latter case, the seams will not ordinarily require soldering.

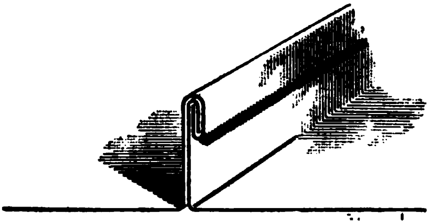


Fig. 46

Before laying the tin, the uneven edges of the roof boards should be smoothed off and the boarding covered with at least one thickness of sheathing paper, to protect the tin from any injurious vapors or gases that are likely to come in contact with the under surface of the tin, and thus prolong the life of the roof. Knot holes in the boarding should be covered with galvanized iron.

For first-class buildings, the boarding for both flat and standing seams should be matched and of even thickness, and the surface should be smooth and free from knots and ridges.

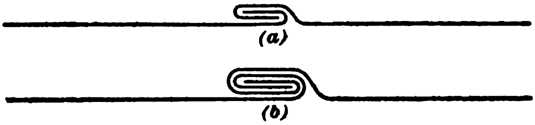


Fig. 47

48. Tin Flashings.—Flashings for skylight curbs, bulkheads, etc. are shown in Fig. 48; those for fire-walls and gable walls, with apron flashings, or counterflashings, are indicated in Fig. 49.

The *curb flashing* shown at *a*, Fig. 48, is nailed on top of the curb *c*, as at *b*, and turned down against it to the roof; it is then carried over the fillet *d*, out on the roof, and seamed and locked to the roof tin at the joint *e*. The *wall flashing* is placed in a raked-out joint *a*, Fig. 49, where it is fastened with flashing hooks; it is then turned down and over the fillet *b* to meet the roof tin *c*, and the two are seamed and soldered together.

The *apron flashing*, or *counterflashing d*, Fig. 49, is placed in the joint *e* and nailed with flashing hooks; it should lap over the wall flashing about 4 inches. The joints *a* and *e* should be pointed with mastic or elastic cement.

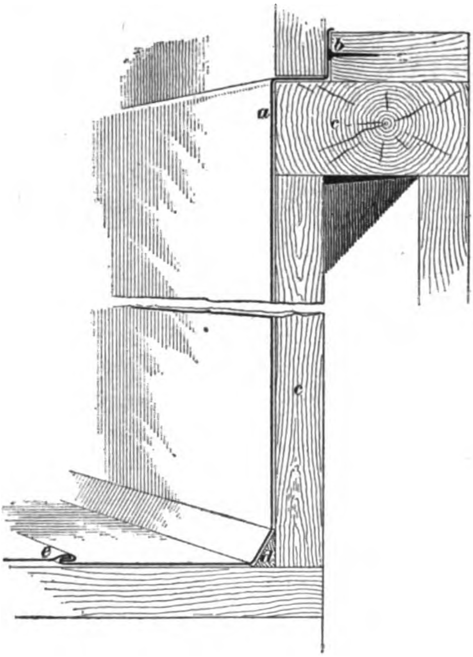


FIG. 48

49. When a tin roof abuts against a chimney or a brick wall, the tin should be turned up enough to prevent water from rising over it. The upstand should be counterflashed with sheet lead or tin. When abutting against a wooden wall, the tin should be turned up against the boarding, and siding or shingles should be laid over it. The tin should also be turned up against all balcony posts, being careful that the edges of the angles are well soldered. The roof should be painted with some good roof paint within a few days after it is laid, particular care being taken that all the rosin has been removed from the tin before the paint is applied. The tin for both flat- and standing-seam roofs should be painted on its under surface before being laid.

50. Amount of Tin Required.—For the sake of economy, sheets of 14 in. × 20 in. or 20 in. × 28 in. are generally used for roofing purposes.

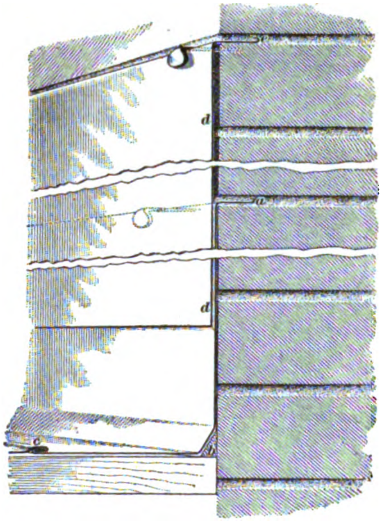


FIG. 49

Measurements in roofing are based on the square of 100 superficial feet; hips, valleys, and flashings are measured by the lineal foot, as are also gutters, down spouts, leaders, or conductors.

One sheet of tin 14 in. × 20 in. covers 235$\frac{3}{16}$ square inches, or 1 foot 7$\frac{1}{2}$ inches, of standing-seam roof. A box of 112 sheets covers 182 feet 14 inches of roof, allowing 1 inch and 1$\frac{1}{4}$ inches for the two side seams, and $\frac{1}{4}$ and $\frac{1}{2}$ inch for top and bottom seams, respectively. In these calculations, no allowance is made for waste of any kind. One sheet 14 in. × 20 in. covers 255 square inches, or 1 foot 9$\frac{1}{4}$ inches of flat-lock roofing, and a box of 112 sheets, allowing $\frac{3}{8}$ inch all around for joints, covers 198 feet 3 inches.

51. Solders.—**Solder** is an alloy of two or more metals. When melted, it adheres strongly to the clean surfaces of other metals that are less fusible. Solders are hard or soft, according to their relative fusibility. Table IV gives the compositions and fusing points of different varieties of solder.

52. When solder becomes impure from use, it may be restored by heating it to 800° F. and adding some sulphur, the mixture being well stirred. The sulphur, combining with the oxides and wastes of the metals, comes to the surface, where it can be skimmed off. By cooling the solder to 400° F., putting in a little tallow to remove the sulphur, and adding tin, the proper quality may be restored.

TABLE IV

COMPOSITIONS AND FUSING POINTS OF SOLDER

Kind of Solder	Hard			Soft			Fusing Point Degrees F.
	Zinc	Copper	Silver	Tin	Lead	Bismuth	
Spelter, hardest	1	2					700
Spelter, hard	2	3					550
Spelter, soft	1	1					
Spelter, fine	2	2	$\frac{1}{4}$				
Silver, hard		1	4				
Silver, medium		1	3				
Silver, soft		1	2				
Plumbers', coarse				1	3		480
Plumbers', ordinary				1	2		441
Plumbers', fine				2	3		400
Tinners'				1	1		370
For tin pipe				3	2		330
For tin pipe				4	4	1	

Too much lead in solder produces a cellular joint and prevents its sweating properly.

53. Fluxes are used to aid in the fusion of solder and to clean the surfaces of metals to be joined. Those commonly used, and the metals to which they are applied, are given in Table V.

54. Melting Point of Metals.—The melting points of the metals used in roofing are given in Table VI.

TABLE V

FLUXES FOR DIFFERENT METALS

Flux	Metals to be Joined
Rosin	Lead, tin, or tinned metals; used with copper bit or blowpipe.
Tallow	Lead, tin, or tinned metals; used with blowpipe or bit, or wiping process.
Sal ammoniac	Copper, brass, and iron; used with copper bit or blowpipe.
Muriatic acid or hydrochloric acid	Dirty zinc; used with a copper bit.
Chloride of zinc	Clean zinc, copper, brass, tin, or tinned metals; used with copper bit or blowpipe.
Borax	Iron, steel, copper, or brass; used with blowpipe.
Rosin and sweet oil	Lead and tin tubes; used with copper bit or blowpipe.

TABLE VI

MELTING POINT OF METALS

Name of Metal	Melting Temperature Degrees F.
Tin	446
Copper	2,100
Zinc	680
Lead	626
Wrought iron	2,912

The fusing point varies greatly, according to the purity of the metal, while the fusing points of alloys vary with their composition.

55. Wall Hooks and Roofing Nails.—Wall or **flashing hooks,** as shown in Fig. 50 (*a*), or at *b*, Fig. 51, hold the flashing in place where it lies against the wall, or they are driven over the apron flashing to prevent it from pulling out; they are usually placed about 16 inches between centers.

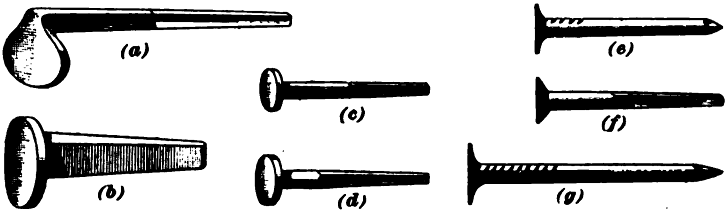


FIG. 50

Wall nails, as shown in Fig. 50 (*b*), are used for the same purpose, but are not so good, as only the shoulder, or under side of the head, bears against the flashing. Wall hooks and nails should be of galvanized iron or of composition metal, to prevent the corrosion of the metals they hold in place.

Tile, shingles, and slate are nailed to the roof with both *cut* and *wire nails*. For shingles or small slate, a cut nail, Fig. 50 (*c*) or (*d*), or a wire nail, Fig. 50 (*e*), of a length equal to the thickness of the roof boards should be used. These nails should be galvanized or tinned. The clean-cut steel nail with countersunk head, shown at (*f*), is generally used for slate.

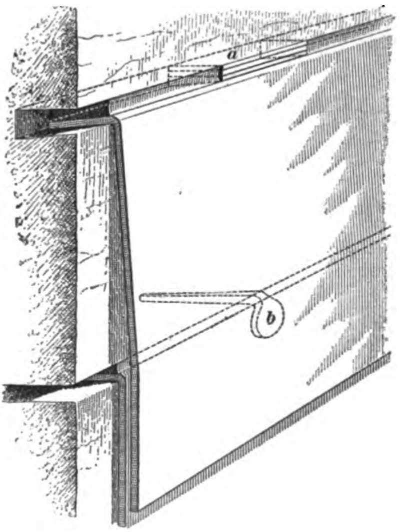


FIG. 51

The copper-wire nail, Fig. 50 (*g*), is used for tiling, and the size is regulated by the kind of tile used and the thickness of the boarding. The thickness of the tile plus the board thickness gives the length. Cut and wire steel nails, galvanized or tinned, are also used for tiles.

For composition roofing, the clout nails, Fig. 50 (*c*) and (*d*), should be used, with or without a tin collar. Composite nails are preferable for all kinds of roofs where nails are used; the best are made of seven parts of copper and four parts of zinc. By their use, the dangers of corrosion and galvanic action are avoided or reduced to a minimum.

Where flashings are placed in a reglet in stonework, they are held by wood or lead plugs or bats, lead being preferred. These bats *a*, Fig. 51, are made up of pieces of lead 1¼ inches long by ¾ inch wide, until a thickness suitable to the joint is formed. They are placed at 12-inch centers, and are driven in and calked in place.

56. Tin Leader Pipes.—Table VII shows the length and diameter of leader pipes made from stock sizes of tin, and the length of pipe that may be made from one box of tin.

TABLE VII

LEADER PIPES

Sheets					Boxes	
Diameter of Pipe Inches	Number of Sheets	Size of Sheets Inches	Length of Pipe		Number Sheets in Box	Length of Pipe Feet
			Feet	Inches		
6⅛	1	14 × 20	1	1½	112	126
4⅛	1	14 × 20	1	7½	112	181
4	2	14 × 20	3	3	112	182
3⅛	1	14 × 20	2	3	112	252
2⅛	1	14 × 20	3	4½	112	278

If, for example, a leader pipe is to be 4 inches in diameter, and the circumference 12½ inches, it is plain that only one length can be had out of a 14″ × 20″ sheet of tin. Allowing ¼-inch lap for each joint at top and bottom, and using two sheets for a length of pipe,

20 in. × 2 − 1 in. = 39 inches, or 3 feet 3 inches

and 39 in. × 56, one-half the number of sheets in a box, gives 182 feet, which is the length of leader sections that may be constructed from one box of tin.

57. Tin Eaves Gutters.—Table VIII gives the length of semicircular eaves gutters that may be made from one box of tin.

TABLE VIII

SEMICIRCULAR EAVES GUTTERS

Sheets					Boxes	
Girth Inches	Number of Sheets	Size of Sheets Inches	Length of Gutter		Number Sheets in Box	Length of Gutter Feet
			Feet	Inches		
19	1	14 × 20	1	1½	112	126
13	1	14 × 20	1	7½	112	182

SHEET-METAL SHINGLE ROOFING

58. Metal shingles take the place of tile, wooden shingles, slate, and other roof coverings. On a pitch of over 30° they make a light and effective roof. These shingles are made of tin, zinc, galvanized iron, copper, bronze, and composition metal, and are manufactured in a variety of shapes and designs. They usually come in single pieces, each forming one shingle, but many makers also furnish a sheet with four shingles stamped on it. Metal shingles are, as a rule, named from their form of outline, and are designated as *Gothic*, *diamond*, *hexagonal*, etc.

59. Laying Metal Shingles.—Generally, metal shingles are laid from the eaves up to the ridge. There is, however, a method of laying the shingles from the ridge downwards. In laying shingles of the Gothic pattern (one of which is shown in Fig. 52), the gutter and eaves flashing should be set as shown at *a*, Fig. 53, the flashings *a* being carried up about 6 or 8 inches on the roof boards; then start at the lower left-hand corner, taking care that the shingles are laid perfectly straight with the eaves. The shingle point should be set back two or more inches, and nailed through the flange *b*. As each row is laid, the gable end flashings *c* should be attached as shown. The ridge is finished as shown at *a*, Fig. 54, and is put in place before the last tier of shingles is laid. In case a whole shingle will not fit into the grooves *b* of the ridge, it should be cut to the proper length.

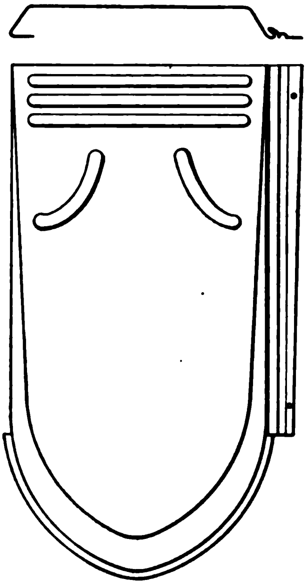


Fig. 52

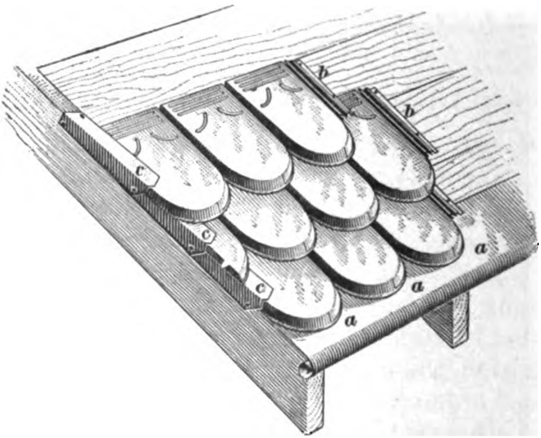


Fig. 53

60. Hips are finished as shown at *a*, Fig. 55, the edges of the shingles being cut to the proper angle and fitted into the groove *b* of the hip flashing.

Valley flashings, shown at *a*, Fig. 56, should be made with a lock or fillet *b* at the edges of the gutter portion. The edges of the shingles are trimmed to the proper angle and turned over with a pair of hand tongs. The shingles are then hooked to the valley fillet, as shown at *c*, and nailed.

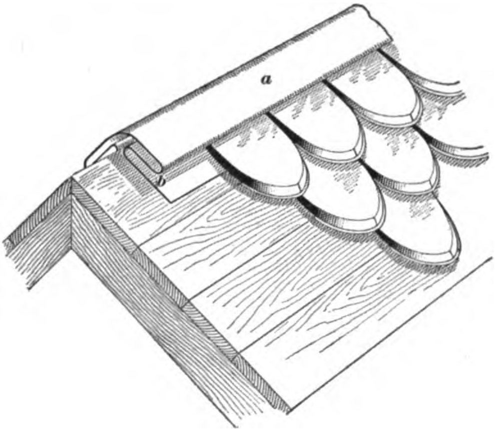


Fig. 54

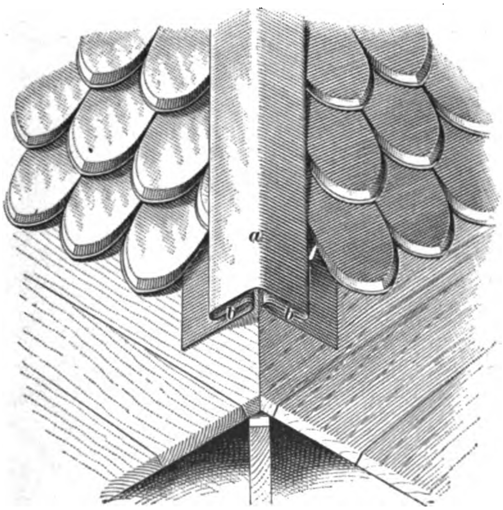


Fig. 55

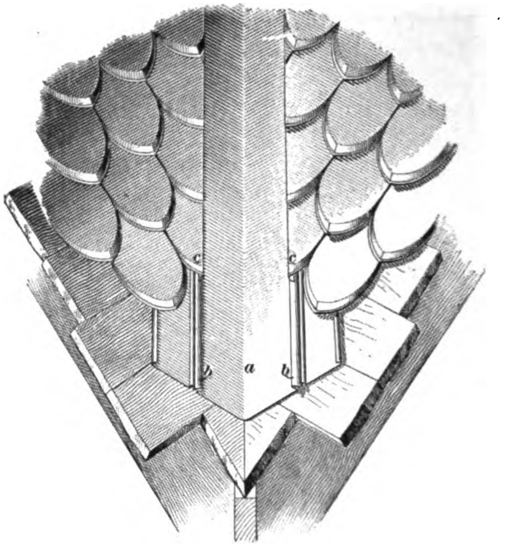


FIG. 56

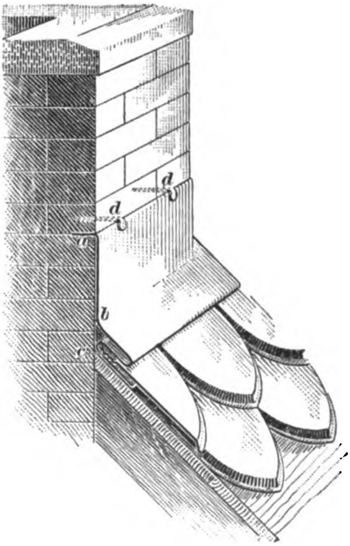


FIG. 57

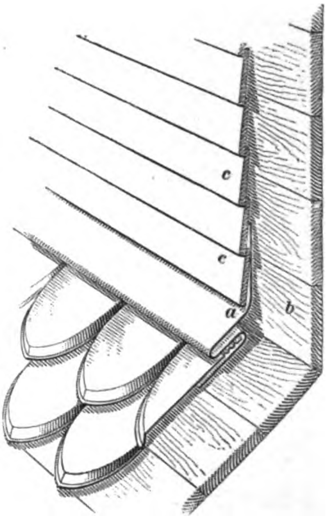


FIG. 58

The chimney and wall junctions are flashed as indicated in Fig. 57. The joints between the brick are raked out as shown at *a*, and a tin flashing of the shape shown at *b* is formed with a groove *c*, into which the shingles are pushed. The flashing, having been inserted into the joint *a*, is fastened with flashing hooks *d*, *d*, and the joint is carefully repointed with elastic cement.

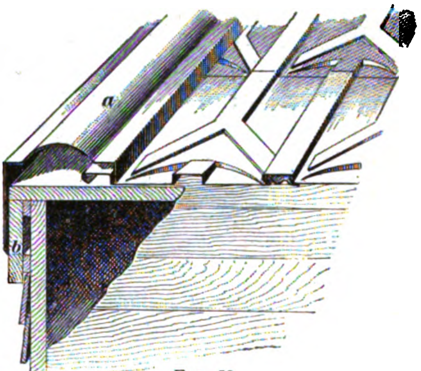


FIG. 59

Dormers and skylights may be flashed as shown in Fig. 58. The flashing *a* is turned up against the sheathing boards *b* and under the clapboards *c*, or other vertical side covering; the edges of the shingles are then carried up and fitted into the groove as shown.

The gable cap and flashing used with square-tailed shingles are indicated in Fig. 59. The molding *a* caps the start of all the rows of shingles and laps over the barge board *b* to which it is nailed.

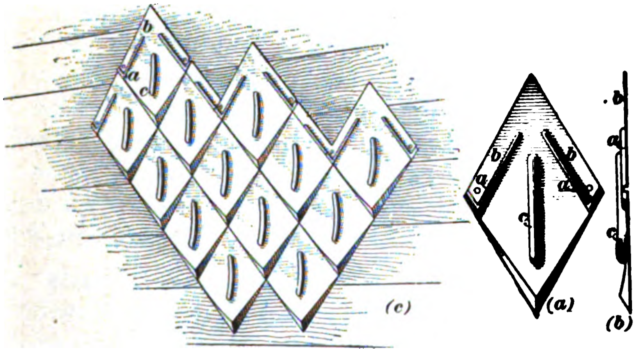


FIG. 60

61. Diamond-shaped shingles, as shown in Fig. 60 (*a*), (*b*), and (*c*), are laid in the same general manner as

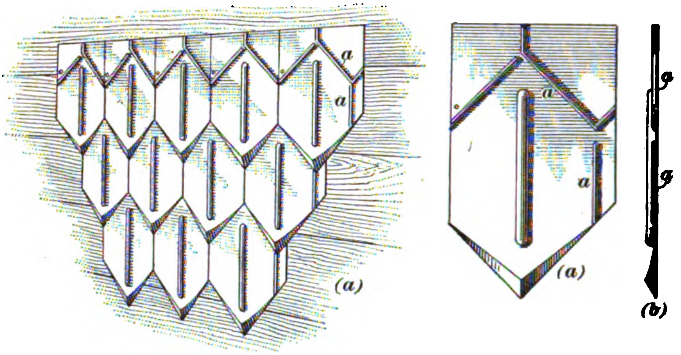


FIG. 61

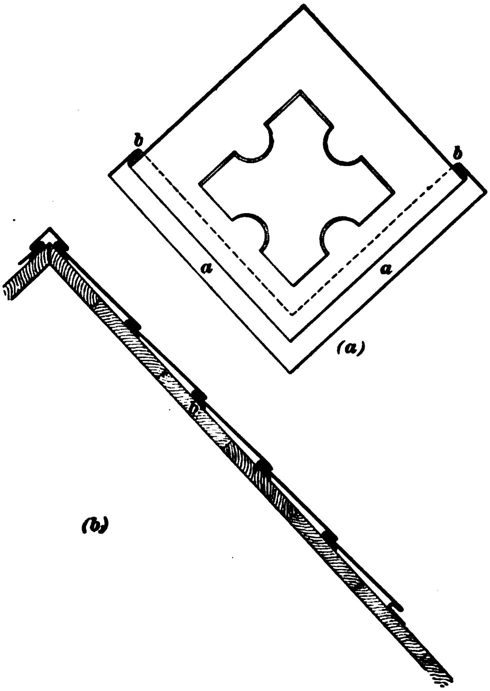


FIG. 62

the Gothic shingles, with the exception that the start may be made from either the right- or left-hand side, as the case may require. The fillet *a* on the two upper flanges forms a water-tight joint. The shingle is nailed through the lower edge of the flange *b* on each side. The central longitudinal rib *c* imparts rigidity and adds to the effect.

Hexagonal shingles, shown in Fig. 61, are of the same construction as the diamond, except that the right-hand flange *a* is extended. The additional fillet necessitates the laying of these shingles from the left to the right.

62. The method of laying metal shingles from the ridge to the eaves is shown in Fig. 62 (*a*) and (*b*). The lower flanges *a* of the shingles are made with a groove *b* into which the next course fits. The ridge cap is the same as that used in the other methods. The chief advantage of these shingles is that all scaffolding is removed as the roof is laid, and all difficulty in making a tight joint at the point of support for the scaffold is obviated.

COPPER ROOFING

63. Properties of Copper.—Copper is distinguished from all other metals by its peculiar red color. Its resistance to corrosion when exposed to the atmosphere, combined with its lightness, gives it great value as a roof covering. Copper is very malleable, ductile, and tenacious, and is found in most countries, the principal mines being those on the shores of Lake Superior in the United States, and at Corocoro, Bolivia, South America.

64. Sheet Copper.—Copper is obtained from its ore by the following process: First, the ore is roasted or calcined; after being roasted, it is melted in a reverberatory furnace, from which it issues in the state called *coarse metal;* this metal is then stamped and pulverized, passed through a furnace, and afterwards melted; the resulting pure metal is roasted and then refined. The copper is then cast into ingots and afterwards rolled into sheets, which are cut to market sizes, varying from 24 in. × 48 in. to 48 in. × 72 in. Sheet copper is supplied in two forms: soft, or annealed, and hard, or cold-rolled. Both varieties may be tin plated, or "tinned," when desired.

65. The gauge, thickness, and weight per superficial foot of copper used for roofing purposes, are given in Table IX.

TABLE IX

GAUGE, THICKNESS, AND WEIGHT OF SHEET COPPER

Gauge Number	Thickness in Decimal Parts of an Inch	Weight Ounces per Square Foot
29	.0134	10
27	.0161	12
26	.0188	14
24	.0215	16
23	.0242	18
22	.0269	20

66. Tests.—The qualities determining the suitability of the sheets for roofing are ductility and strength, and uniformity of gauge or thickness. The gauge, which varies from 1 to 30, must be as represented, and tested with a wire gauge, and the sheet must be of the full weight, corresponding to the gauge, which, in common use, ranges from 10 to 20 ounces per square foot. When a piece is broken off, the fiber should present a bright, lustrous, and silky appearance, if the copper is of the best grade. The metal should also bear stamping into form without developing fractures.

67. Laying Copper Roofs.—The methods employed in laying copper roofs are usually the same as those required for tin roofing, although the flat roof laid with a lap seam is not to be commended. It is weak, and, being soldered and nailed, will not permit sufficient expansion and contraction. Where solder is used, the lock-seam with cleats is best. The edges of the sheets and all surfaces with which they come in contact should, before the seaming and folding are done, be thoroughly cleaned with chloride of zinc. When the sheets are in place, mallet them down to the roof. In case the metal is tinned on one side, the folds should be turned so that the tinned surfaces shall face each other. Tinning is resorted to so that the solder may flow or sweat more freely than it will on the copper. The solder used for copper roofs is the same as is used for tin roofing.

The standing-seam method of laying should be employed where extra strength and stiffness are required, on very steep-pitched roofs, and on flat surfaces where work without solder is to be carried out.

68. **Roll-joint copper roofing** is laid in two ways. In the one, the roll is hollow and is secured to the roof by *clips*, or *tingles;* in the other, a solid roll is used, set with a trough or nailed directly to the roof. Fig. 63 shows the hollow roll. The clips, or tingles, *a*, *a* are nailed to the roof before each sheet is laid; against the clips, or tingles, the edges of the sheets *b* are turned, and the left-hand sheet is bent over to form the lock *c*. This joint, or lock, is seamed and then turned over in a roll, as indicated by the dotted lines and the completed roll *d*.

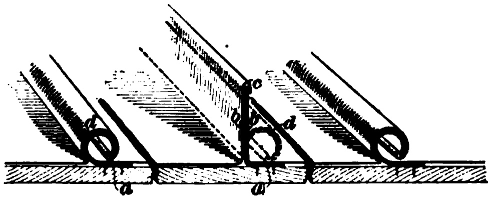


FIG. 63

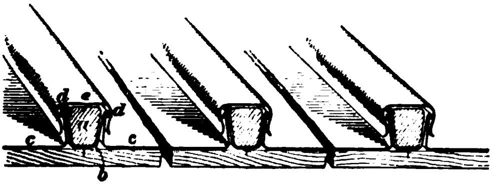


FIG. 64

69. The **trough method** is illustrated in Fig. 64. The wooden strips *a* are 1½ in. × 2 in. The trough *b* made of copper, in which the strips are set, is nailed to the roof boards; the sheets *c* are then bent up to the top of the trough and the edges *d* of

the trough are locked or turned down over them. The cap *e* is made as indicated, and is sprung tightly over the strip.

The solid roll, shown in Fig. 65, has the roofing plate *a* bent up and over it, the upper sheet being the last put in place between the rolls as the covering is laid. This, under ordinary circumstances, makes a good roof.

70. To save time and labor, flashings or other vertical jointed work should be soldered, when required, before being taken on the roof. When the sheets are in place, the solder will not flow into the vertical joints; but on the ground, the sheets may be laid so that the solder will readily flow into the seams.

Connections between the flashings of the walls, chimneys, etc. and the gutters should be double-locked, and to permit free movement they should not be soldered.

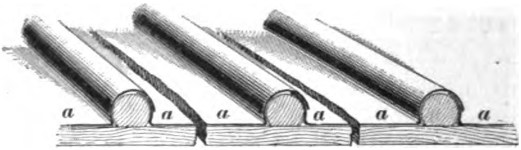


FIG. 65

71. Copper Tiling.—Copper roofing tiles are made in imitation of most of the different forms of terra-cotta tiles. They are extensively used, principally on account of their cheapness and lightness. Like all other tiles, they are generally laid by beginning at the eaves and continuing to the ridge. Great care must be taken in laying the first course, called *starters*. On this depends the appearance of the entire roof, for if the starters are out of line horizontally, the finishers at the ridge will show the same defect; and should there be intercepting roofs, this defect will also show at the valleys.

72. A common form of copper tile used is the imitation of the Spanish clay tile, as shown in Fig. 66. This pattern is interlocking, and is secured to the roof with nails driven through the right-hand flange *a*. The fillet collar *b* near the upper end forms the horizontal joint with the tile above, and the sides connect with a vertical side lock, as shown at *a*, Fig. 67, rendering them water-tight. At *b*, Fig. 67, is the flange, which is nailed to the roof.

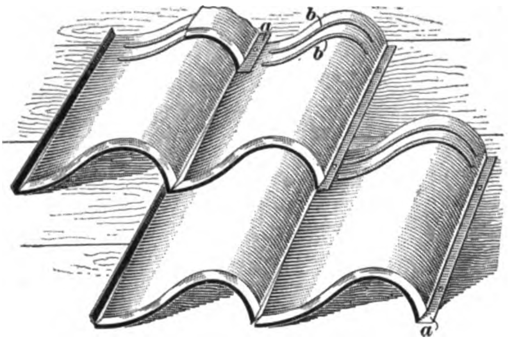


Fig. 66

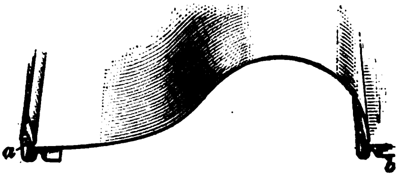


Fig. 67

73. Copper rolls for ridges and hips to go with the tiles are made in many styles, the most common one being shown at *a*, Fig. 68. On the hips, the tiles should be cut to the proper angle and fitted to the hip strip *b*; the roll is then placed over the hip strip and the tiles and is fastened by nailing through its flanges.

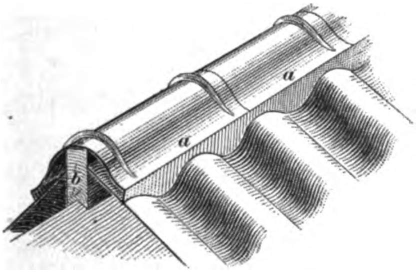


Fig. 68

Tile for the valley must be cut in the same way, the open ends of the tile being closed with pieces cut to the shape of the tile and soldered in. Where these tiles are used, the valley flashing should never be less than 20 inches wide.

In nailing the gutter tile in place, care must be taken not to drive the nails into the gutter, under the side lock, as it would cause the roof to leak.

Flashings should be constructed in the manner shown under the heading Tin Roofing, and of 14- or 16-ounce copper. All valleys and gutters should be made of 16- or 18-ounce copper.

74. Conical Roofing.—Conical-tower roofs may be covered with two kinds of special copper tile, which is graduated to correspond to the pitch. These tiles are shown in Fig. 69, the one at (*a*) being flat and the one at (*b*) being round.

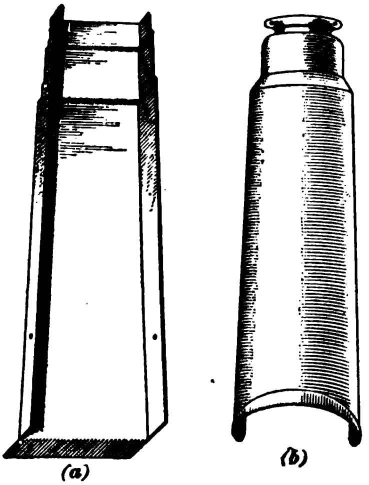

(*a*) (*b*)

FIG. 69

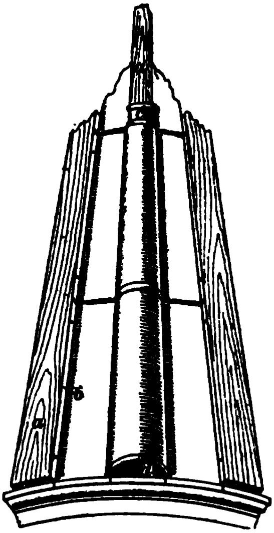


FIG. 70

The roof is prepared to receive these tiles by attaching wedge-shaped strips of wood to the sheathing, as shown at *a*, Fig. 70. The upturned edges of the flat tile are nailed to the strips as shown at *b*; the round tiles are then placed over the strips, lapping the edges of the flat tile, and are fastened by nailing the upper end as at *c*, the lower, or butt, end *d* being nailed into the end of the wooden strip.

75. Sizes of Tiles and Material Required.—For straight surfaces the following sizes of tiles are used: 7 in. × 10 in., 10 in. × 14 in., and 14 in. × 20 in. The last size is best adapted for large roofs, but for ordinary roofs 10 in. × 14 in. is the size recommended. These tiles may be made of 12-, 14-, or 16-ounce copper.

A square will require four hundred 7″ × 10″ tiles; one hundred and seventy-four 10″ × 14″ tiles; or seventy-two 14″ × 20″ tiles. These quantities allow for laps, waste, cutting, etc.

GALVANIZED SHEET-IRON ROOFING

76. Galvanized iron is iron coated with zinc, the object being to protect its surface from the rapid oxidation that takes place when it is exposed to atmospheric influences. The zinc coating is applied to the plates while they are heated, the plates being previously prepared by cleaning and dipping in various chemical solutions, as sulphuric acid, and the salts of chloride of zinc, or sal ammoniac. The coating should be uniform in thickness and should cover the entire surface.

77. To test the quality of galvanized iron, take a small piece of the iron, bend it double, and pound it down close; if no fracture is shown, the iron is of a good quality. A more severe test is to again flatten it out, without the material showing fracture. Samples may be tested for thickness of coating by greasing them and holding them over a gas jet; the amount of fusible metal flowing off will determine the character of each sample.

78. The sheets ordinarily used for roofing are from No. 16 to No. 28 gauge, and vary in weight from No. 16 at 3 pounds per square foot down to No. 28 at $\frac{3}{4}$ pound per square foot.

79. Corrugated Roofing.—The best grade of roofing is made from double-refined box-annealed iron. The corrugations are made either by passing the sheets through rolls or by pressing the sheets, the latter process making the most perfect and uniform corrugations. The thickness of the metal to be used will depend on the distance between the supports on which the sheets are laid, the lighter gauges being laid on close sheathing, while the heavier gauges can be laid on supports spaced from 2 feet to 5 feet apart. The pitch of the roof on which corrugated sheets are laid should not be less than 3 inches in 1 foot. The sheets should have a lap of at least 4 inches on the roof boards. Where the sheets abut against a fire-wall, an edge *a* should be turned up about 6 inches, secured to the wall with wall hooks, and covered with an apron flashing *b*, as shown in Fig. 71 (*a*); otherwise, first lay a flashing *c* and carry the roofing over it and counterflash, as at *d*, Fig. 71 (*b*).

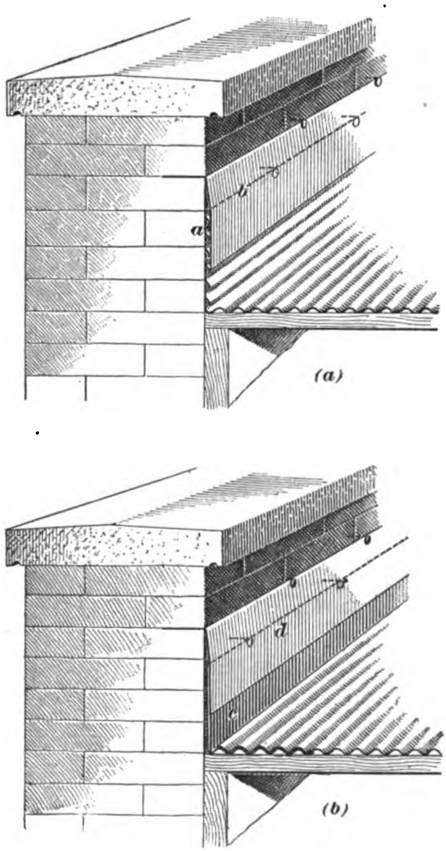
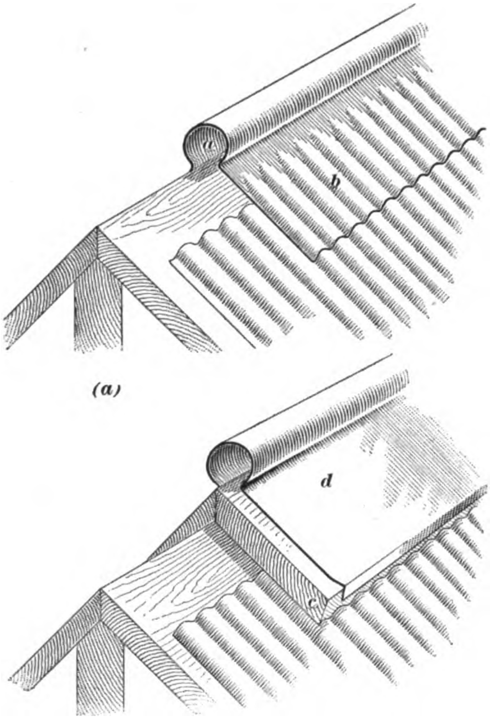


Fig. 71

80. Ridges should be finished by a ridge roll, or cap, *a*, as shown in Fig. 72 (*a*), having an apron, or wing, *b* corrugated to suit the corrugations of the sheets, or, as indicated in Fig. 72 (*b*), a ridge board *c*, having its lower face corrugated to match the sheets, may be attached to the roof and then covered with a plain cap *d*.



(a)

(b) FIG. 72

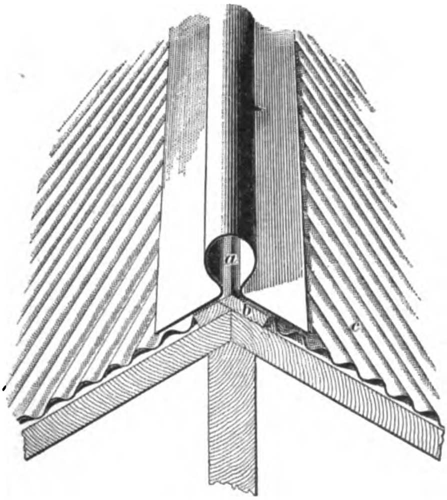


FIG. 73

Hips should be finished as shown in Fig. 73 by cutting the iron sheet *c* to connect with the hip strip *b* and then covering the joint with a hip cap *a*.

Valleys should be formed of plain sheets of galvanized iron, from 18 to 24 inches wide, the ends being lapped at least 6 inches. Corrugated iron is cut to the proper angle and fitted over the valley, the sheets lapping for a distance of 6 inches over the edges.

In fitting around chimneys, bulkheads, etc., the sheets on the lower side *a* and flanks *b*, Fig. 74, should abut against the chimney; a flashing should be turned up against the chimney 5 or 6 inches; as at *c*, and counterflashed, as at *d*. The tops of the two flashings are secured with wall hooks.

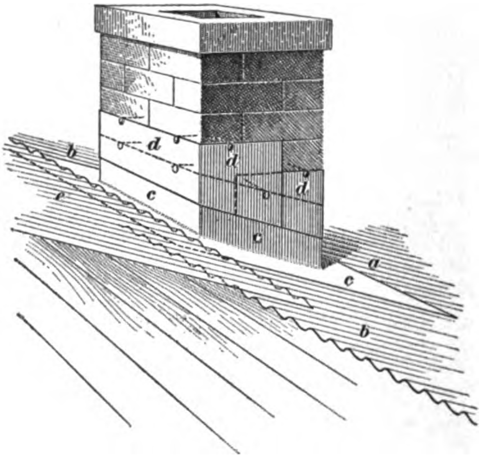


Fig. 74

81. Corrugated Siding.—When corrugated sheets are used for siding, the sheets should have a lap of at least 1 inch at the ends and one corrugation at the edges of the sheets. The edge laps should be nailed every 6 inches, and the end laps in every other corrugation. If the metal is put on studding, the studs should be spaced to suit the width of the sheet used. If the height is greater than one sheet, a piece of studding should be put in horizontally, at the proper height, to take the end laps. If applied to rafters without boards, the rafters must be spaced to suit the width of the sheets, and a piece of studding must be put in between each rafter where the sheets join at top and bottom, and also midway between, to prevent sagging.

Another method is to set the rafters to suit the width of the sheet and cover them with strong slats, bringing up the rafter edge with a piece of the same material.

82. Flat Sheeting.—In preparing the material for flat sheets laid with wooden rolls, the sheets are riveted together, end to end, the rivets being placed about 1 inch apart, making a continuous sheet from eave to ridge; or each sheet may be laid with a lock-seam, as described for copper roofs.

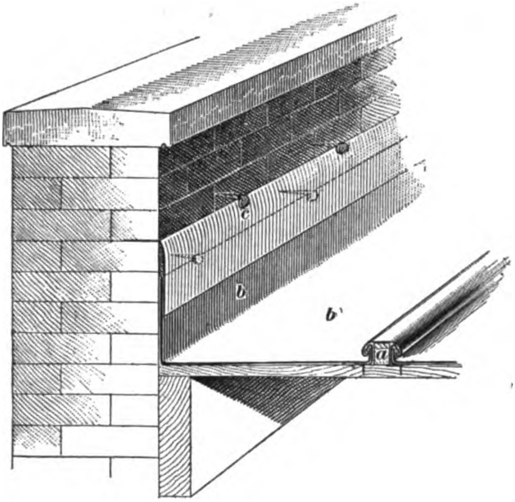


FIG. 75

The eaves gutter, or flashing, should be attached to the roof before laying the roof proper, and should lap the roof boards not less than 4 inches.

The wooden rolls or strips *a* in Fig. 75 are attached to the sheathing, and spaced to suit the width of the sheets. Against a fire-wall or parapet wall, a sheet *b* will be required, which will be counterflashed as at *c*. Clips 2 inches wide by 5 inches long should be attached to the edges of the rolls. The method of securing the sheets by the clips and rolls is shown in Fig. 76, in which *a* is the clip; *b*, the sheet; *c*, the lock; and *d*, the cap roll. The cap roll is slipped over the wooden roll, the edges of the roll passing over the throating formed by the ends of the clips *a*, *a*, which thus hold it in place. The horizontal end joints are made with a single lock, and are fastened to the roof by clips in the same manner as in the roofing.

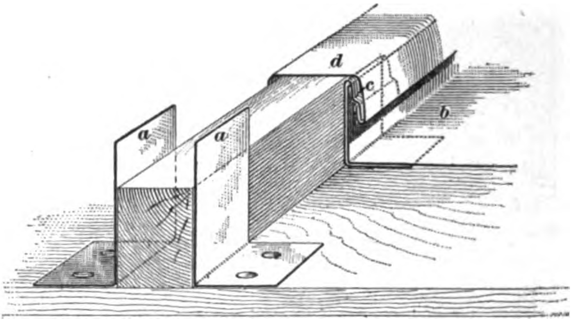


FIG. 76

83. Tables Showing Quantities and Dimensions. Table X gives the amount of galvanized corrugated sheet iron required to lay one square.

TABLE X

CORRUGATED SHEET IRON REQUIRED FOR ONE SQUARE

Side Lap	Corrugation Inches	Length of End Lap, in Feet					
		1 Inch	2 Inches	3 Inches	4 Inches	5 Inches	6 Inches
One corrugation lap	2½	110	111	112	113	114	115
One and one-half corrugation lap	1¼	110	111	112	113	114	115
	¾	105	106	107	108	109	110

Table XI gives the width, depth, and number of corrugations to a sheet and the covering width, deducting lap.

TABLE XI

WIDTH, DEPTH, AND CORRUGATIONS OF SHEET IRON

Width of Corrugation Inches	Depth of Corrugation Inches	Number of Corrugations to Sheet	Width of Sheet After Corrugation Inches	Covering Width After Lapping One Corrugation Inches
2½	½ to ⅝	10	26	24
1¼	⅜ to ½	19½	26	24
¾	¼	34½	26	25

Table XII gives the gauge, thickness, and weight, in pounds per square foot, of galvanized sheet iron:

TABLE XII

GAUGE, THICKNESS, AND WEIGHT OF SHEET IRON

Gauge Number	Thickness Inch	Weight Pounds per Square Foot
16	.065	3.00
17	.058	2.69
18	.049	2.31
19	.042	2.07
20	.035	1.75
21	.032	1.50
22	.028	1.32
23	.025	1.19
24	.022	1.06
25	.020	1.00
26	.018	0.96
27	.016	0.88
28	.014	0.75

BLACK SHEET-IRON ROOFING

84. Black sheet iron for roofing is furnished cold-rolled and annealed, in gauges ranging from 16 to 26 and in weight from ¾ pound to 2½ pounds per square foot. Anything lighter than gauge 26 is not recommended. The sizes of the sheets vary from 24 in. × 72 in. for the lighter gauges to 30 in. × 84 in. for the heavier weights. The sheets should be free from flaws or holes, and uniform in thickness and ductility.

Paper and felt are not, as a rule, used under iron, but their use, it should be observed, tends to make the roof more enduring, protecting it from gases underneath and from sweating.

85. Standing-Seam Roofing.—Sheet iron is usually laid with some form of standing seam, with or without a cap, on the interlocking pattern, with the same kind of joint as in the case of metal tiles or shingles.

Standing-seam roofing with cap is prepared by locking and seaming the sheets together, end to end, thus forming a continuous sheet the full length of the slope of the roof. The edges are then turned up or flanged 1 inch high and fastened with cleats *a*, as shown in Fig. 77; these cleats are made of metal 2 inches wide, having a bearing on the roof of 2 in. × 1½ in. The upstanding part of the cleats is cut down the middle, as shown at *b*, 1⅝ inches, and one section *c* of the divided cleat is bent over the flange of the sheet *d* first laid. The sheets of the second row *e* are then flanged and placed against the clip *a*, whose other half *b* is turned over this flange, as shown at *f*.

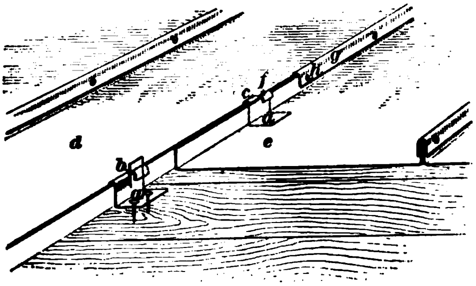


Fig. 77

The flanges are then gone over, clamped or seamed up close and tight, and the cap *g* is put on. This cap should be clamped securely in place. Holes *h* are then punched through the cap and flanges about 15 or 16 inches apart, and $\frac{1}{8}$-inch rivets are used to bind the parts together. A washer should be placed on each end of the rivet, and the head should be formed with a rivet set.

86. Fig. 78 shows a method of finishing the roof at the eaves, when a gutter is used. The roof has standing seams as shown at *a*. The gutter is turned back on the roof about 4 inches as shown at *b*, the roof being locked into the flange *b* of the gutter and pounded down with a mallet. The outside edge *c* is bent down over the gable fascia about 1 inch and nailed as shown. Hips in this style of roofing are made by cutting the sheets to the proper angles, but making an allowance of 2 inches, then turning or flanging this 2-inch section, and capping it in the same way as the other joints.

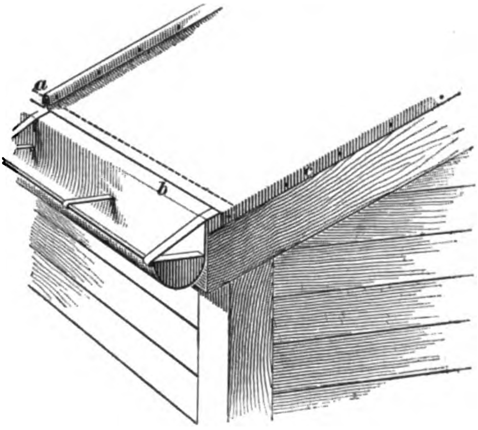


FIG. 78

Valleys are formed of full-width sheets, 24 inches wide. A $\frac{1}{2}$-inch single lock is formed on the sheets on each edge of the valley, which should be secured to the roof with clips to fit the lock, as in flat-seam tin roofing. A flat lock is then formed on the roofing sheet, and both are locked together and seamed down.

Flashings are constructed in the same manner as for the metal roofs already described.

87. Double-seamed roofing, shown in Fig. 79, has another form of standing seam. This roofing is put up in rolls, the same as capped roofing, and the sheets are joined end to end by a single lock-seam. It may be at once seen that with this roofing no caps or fastenings of any kind are used, except the cleats *a*, which are nailed to the roof at the same centers as for the cap roofing. The sheets are turned up 1¼ inches on one side *c*, and 1½ inches on the other side *b*. The 1½-inch side is turned over the 1¼-inch side, as at *d*, and the whole seam is then turned over and down again, forming the double seam *e*, from which the roofing obtains its name. The flashings are the same as those before described. This method guarantees an enduring and water-tight roof.

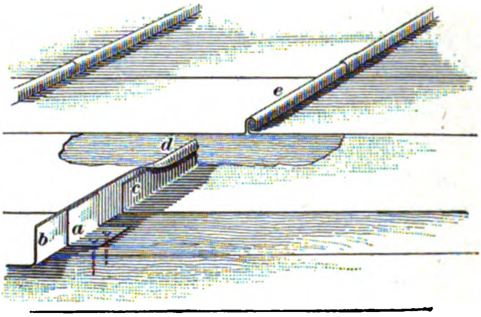


FIG. 79

88. The *interlocking* pattern shown in Fig. 80 consists of sheets with a single lock *a* at the top and bottom of the sheets, and a vertical lock *b* at the sides. The plates are attached to the roof by nailing through the side flange *c*. The chief merits of this method are that no cleats, rivets, or anchors are employed, and a great saving of time and labor

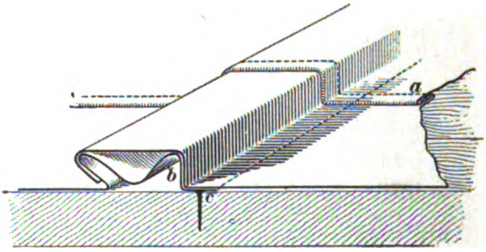


FIG. 80

is effected. The roof appears as if laid with rolls, and the peculiar pattern of the side lock gives the roof strength and makes it very rigid and durable.

89. Dimensions of Black Sheet Iron.—Table XIII gives the gauge, thickness, and weight, in pounds, of black sheet iron per square foot.

TABLE XIII

GAUGE, THICKNESS, AND WEIGHT OF BLACK SHEET IRON

Gauge Number	Thickness Inch	Weight Pounds per Square Foot
16	.065	2.61
17	.058	2.33
18	.049	1.97
19	.042	1.69
20	.035	1.40
21	.032	1.28
22	.028	1.12
23	.025	1.00
24	.022	0.88
25	.020	0.80
26	.018	0.72
27	.016	0.64
28	.014	0.56

SHEET-LEAD ROOFING

90. Roofing Lead.—Lead, the softest metal in general use, is extremely pliable, very malleable, flexible, and heavy, but is lacking in tenacity and elasticity. It is mostly found in combination with other ores, the principal mines being at Leadville, Colorado; in Derbyshire, England; the Harz Mountains, Germany; and the southern part of Spain.

Lead is reduced from an ore called *galena*, by roasting or smelting in a reverberatory furnace furnished with long flues, to catch the particles of lead precipitated by the fumes. *Sheet lead* is either cast or milled. *Cast lead* is thicker and heavier than milled lead, and has a harder surface. Being, however, liable to flaws, such as sand holes, etc., and irregular in thickness, it should not be used if lighter than 60 pounds per square foot.

Milled lead is rolled thin, is more uniform in thickness than cast lead, bends easily, and when worked gives neater and better results. This lead, however, is liable to crack from the continual expansion and contraction due to heat and cold, or on exposure to the sun's rays.

Lead is always designated by its weight per square foot, and not by gauge.

91. Laying the Roof.—Roofs covered with lead should have a pitch of not more than 1 inch to the foot. The boarding under a sheet-lead roof should be more carefully laid than for any other metal; the boards should be narrow and matched, and run with the current or pitch. If the boards are not blind-nailed in the joints, the nails should be set. The boards should also be well planed at the joints, to make a smooth surface, and, to prevent warping, should be thicker than is usual in such places. Planking 1½ inches thick gives good results.

For sheet-lead roofing, it is best not to use sheets measuring more than 3 ft. × 8 ft., as the expansion and contraction in such a case is liable to make the roof defective. The size in most common use, however, is 2½ ft. × 6 ft. The sheets of lead should not be secured by nailing or soldering, but should be left free, to allow for expansion.

92. The *junctions* employed in lead roofs are called **rolls** when laid in the direction of the pitch, and **drips** when laid at right angles to the pitch. The rolls are made from 2 to 3 inches in diameter, having the upper surface round and the lower corners left square, as shown in Fig. 65. The edges are called overlap or overcloak, the latter being the edge of the sheet turned over the edge of the succeeding sheet and dressed down, forming the roll. Hollow rolls for sheet lead are constructed in the same way as for copper roofs, as was shown in Fig. 63.

The clips, or tingles, between the sheets of a lead roof must not be spaced more than 20 inches apart.

Nosings are the rolls formed at the angle between the horizontal surface of a flat roof and the sloping sides of a roof, as shown in Fig. 81. The flashing *a* on the sloping surface is turned up and nailed to the edge of the flat roof or deck plank as shown, and over this is nailed a wooden nosing *b*. The edges of the sheets *d*, *d* are locked into and secured by clips *c*, *c* let into a rabbet in the edge of the flat roof; the sheets *d*, *d* are then bent over the nosing in the form of a drip, as shown.

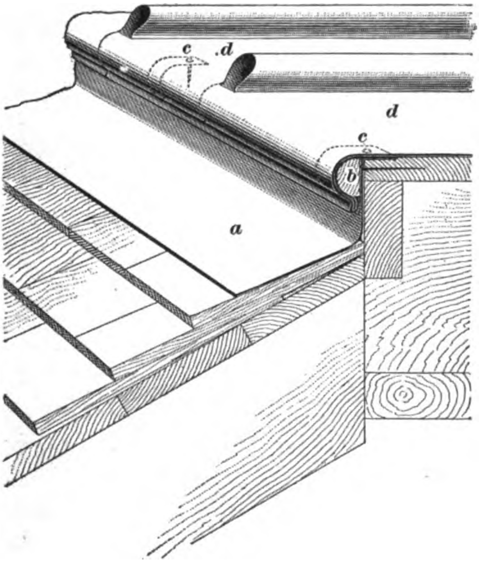


FIG. 81

A **lock**, or **welt**, is an ordinary single lock-joint used instead of a roll on flats, where there is a sufficient pitch. Although this kind of a joint takes less metal, it is not recommended.

On hips and in valleys, a lapped joint is commonly used. This is made by lapping one sheet 5 or 6 inches over an adjacent one, dressing the edges and malleting them down flat.

Drips are joints made across the current of the roof, and are located according to the length of the sheets used. They are constructed in two ways, as shown in Fig. 82 (*a*) and (*b*).

In the first method (*a*), the sheet on the lower level *a* is bent up and over the step *b*, the edge being let into a rabbet, cut for it in the boarding of the higher level, and nailed securely, as shown. The upper sheet *c* is then lapped over it and turned down. To avoid capillary attraction, there should be a space of at least $\frac{3}{4}$ inch between the edge of the upper sheet and the sheet on the lower level.

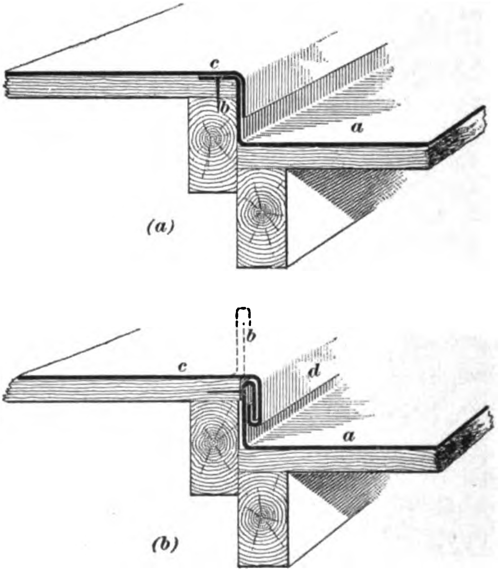


FIG. 82

In the second method (*b*), the lower sheet *a* is bent so as to extend $1\frac{1}{2}$ inches above the upper level, as indicated by the dotted line *b*. Sheet *c* is bent up and over the edge of the lower one, and the two sheets are then folded over and downwards, forming a lock *d*, as shown.

93. In covering small angular or curved surfaces of woodwork, it is necessary to fasten the lead to the woodwork with screws, to keep it in place; this is done as shown in Fig. 83. The boarding *a* is countersunk, and the lead *b* is formed into the cavity and secured in place with screws *c*, *c*. The cavity *e* in the lead is then filled with molten solder, to protect the screw heads and render it water-tight. The solder should be made to flow under the screw heads to prevent the sheet from tearing.

94. Lead flashings are constructed in nearly the same manner as other metal-roof flashings, the chief difference being the manner of securing the upper edge to the masonry or brickwork. As with other metal flashings, wall hooks may be driven in the joint over the apron or counterflashing. Plugging with lead is, however, preferable to all other methods. These plugs are about 1¼ in. × 2 in., and are made to suit the joint in the masonry, or the reglet cut therein to receive the flashing. After the plugging, the joint or reglet must be pointed up with mastic or elastic cement. Burning in makes the most permanent joint. The flashing is inserted in the reglet, which is then filled with molten lead and calked in. This method, is, in most cases, very difficult to execute properly, on account of the position of the joint. Unless the joint is in

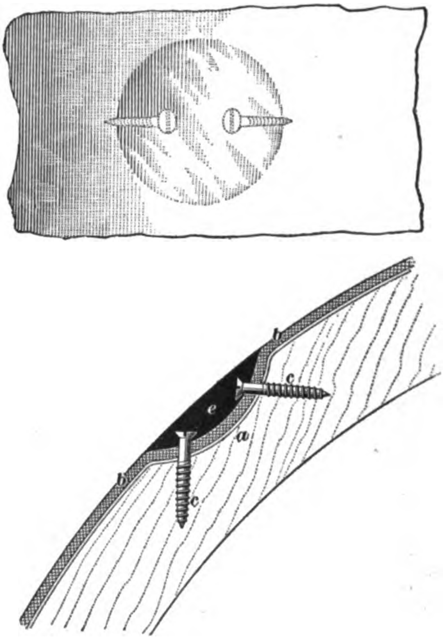


FIG. 83

a location that is very much exposed, the plugging will be sufficient.

95. Lead gutters should have a current, or fall, of at least $\frac{1}{4}$ inch to the foot, and the joints between the sheets should be formed where possible with drips, the same as mentioned for flats. The sides of gutters abutting the walls should be turned up 6 or 7 inches and counterflashed, the ends of the gutters being bossed, or folded up, and soldered.

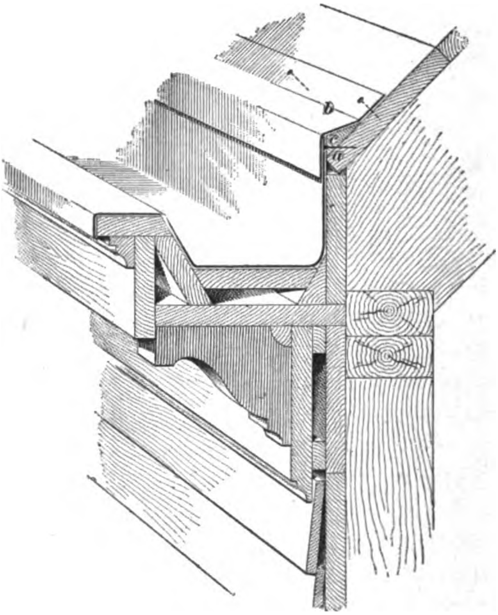


FIG. 84

Trough gutters should have the outside edge turned over the wood or stone crown member, and left without fastening. The inner side should be carried up at least 4 inches above the outer edge and over a tilting fillet on the roof, or it may be stopped off at the board line. Where the gutter is not very wide, the counterflashing may be dispensed with, and the gutter lining, as shown in Fig. 84, may then be simply flanged over the tilting fillet. When the gutter lining is stopped off at the fillet, or roof line, it should be covered with a counterflashing *b* nailed over the tilting fillet *c* to the roof boards *a*. When a gutter comes against the back of a horizontal parapet wall, the wall should be pierced about 5 inches above the lowest part of the gutter, and an overflow should be provided to take off any excessive fall of rain on the roof, or to provide an overflow in case the leader becomes stopped up by leaves or dirt. If the gutter is very long, there should be more than one outlet.

In working lead flashes around corners and in angles, great care should be taken to avoid sharp angles, otherwise the lead is likely to be cut.

The following weights of lead for the different parts of a roof are generally applicable: For flats and gutters, 6 to 8 pounds per square foot; for flashings, 5 pounds per square foot; for hips and ridges, 6 to 7 pounds per square foot. Where the roofs are very much exposed or where temperatures are extreme, heavier lead should be used.

TABLE XIV

THICKNESS AND WEIGHT OF ROOFING LEAD

Thickness Inch	Nearest Simple Fraction	Weight Pounds per Square Foot
.068	$\frac{1}{16}$	4
.085	$\frac{5}{64}$	5
.101	$\frac{3}{32}$	6
.118	$\frac{7}{64}$	7
.135	$\frac{1}{8}$	8
.152	$\frac{9}{64}$	9

96. For lead roofs or flats much walked over, a wooden-slat floor should be laid. In using lead for gutters with slate or tile roofing, the more the roofing can cover and protect the lead from the sun, the longer the lead will last. In using lead for apron flashing or counterflashing, on very steep gables, the stepped-flashing method is to be preferred, as it keeps the lead in position; if laid in long pieces, the lead is liable to crawl and stretch until it becomes too thin to be of any value.

The thickness and the weight per square foot of lead used for roofing purposes are given in Table XIV.

SHEET-ZINC ROOFING

97. Zinc, one of the useful metals, generally extracted from mountain limestone and magnesium limestone in conjunction with galena, is met with abundantly in the form of a sulphuret. The ore is roasted, mixed with charcoal, and heated in special retorts. The zinc is converted into vapor, condensed, and fused.

Cast zinc is brittle when cold. Heated to 200°, it is ductile as well as malleable, and may be rolled into sheets that will retain these properties at that temperature; while, if the temperature is allowed to exceed 400°, the zinc will return to its original condition of brittleness. When exposed to the air, at a high temperature, it will burn and be consumed.

Zinc is easily acted on by moist air, but a film of oxide is soon formed and thus protects the metal from further action. Its expansion and contraction are greater than that of any other common metal. Zinc is very rarely used for roofing purposes in America, its use being mostly confined to European countries.

Good zinc should be free from iron, and zinc containing more than 1 per cent. of lead should be rejected, the lead making it brittle. Good sheet zinc is uniform in color, tough, and easily bent backwards and forwards without cracking. Inferior zinc is dark in color and has a blotchy appearance, caused by the presence of other metals. The conjunction of the dissimilar metals is liable to set up galvanic action, which soon destroys the zinc.

Zinc should not be secured by, or connected with, iron, copper, or lead, for, in any of these cases, voltaic action is induced, which destroys the zinc.

98. Zinc is described by the weight and the thickness of the sheets to the superficial foot. The gauges used for roofing run from 13 to 16. The weights of these gauges run from 1 pound to 1 pound 8 ounces per square foot. The width of sheets varies from 24 to 52 inches, and the ordinary length of sheet varies from 6 to 10 feet, but zinc may be obtained in long rolls of any desired lengths.

99. Methods of Laying.—Solder should never be used in zinc roofing except for the small vertical joints of flashings. Before soldering, the joints are fluxed with muriatic acid. Paper or felt should always be used under zinc where it comes in contact with woodwork containing acids, as, for instance, oak; otherwise, these acids cause the zinc to corrode.

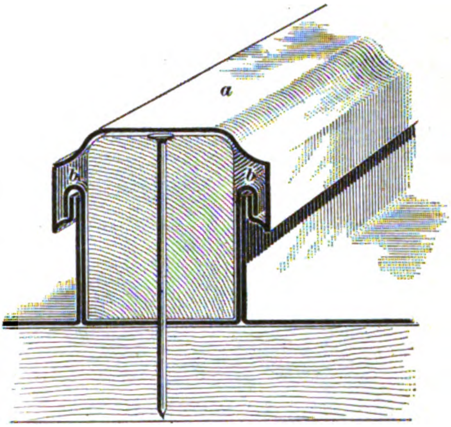


Fig. 85

The methods employed in laying zinc roofing are hollow roll, wooden roll, trough and cap, and standing seam. They are the same as employed in laying copper roofing and described in the preceding articles, with the exception of the trough-and-cap method shown in Fig. 85, the difference being that the cap *a* is slipped over the lock *b* of the trough, and clips are not required to keep it in place. The flat portions of the roof are fastened with clips at the head of each sheet, made to fit into the lock-seam, the clips being nailed to the roof boards. The sides of the sheets are fastened by locking or seaming over them the edges of the

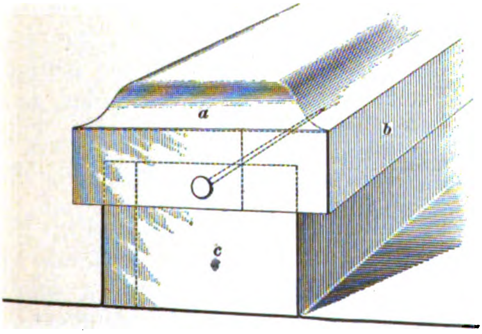


Fig. 86

trough *b*. The ends of the rolls should be closed, or stopped, by turning down a portion of the roll cap *a*, Fig. 86, against the wooden roll, and by folding the corners of the sides of the cap *b* and trough *c* under this end.

If the roof is very flat, drips should be used at the end of each sheet, as described and shown for lead roofing in Fig. 82. The lower edge of the sheets, next to the eaves, should be strengthened by turning or doubling it back so as to form a bead, or by locking it to the gutter edge, where it joins the roof.

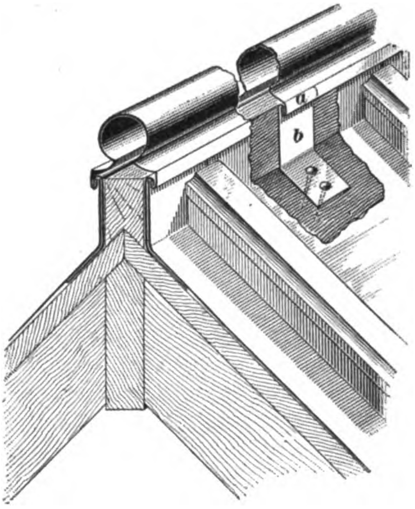


FIG. 87

Where there is no boarding, corrugated roofing is generally employed, the corrugations giving the plates strength. Soldered or rigid connections are to be particularly avoided, and the joints must be so arranged as to be weathertight, but allowing free movement for expansion and contraction.

Corrugated zinc is laid with the flutes running up and down the incline, the sheets overlapping one corrugation at the sides, and 4 inches at the ends where connections are made. This method is shown under the heading Galvanized Sheet-Iron Roofing.

Ridge caps or rolls should have the edges *a*, Fig. 87, turned up and under, to make a strong edge, and should be secured in place by slipping the edge over the clips *b*, which are placed at intervals of 15 inches and nailed to the ridge. The cross-seams where the lengths of the caps meet are closed with a single lock seam.

Flashings for chimneys are the same as for other metal roofs, except that no other metal but zinc should be used, on account of the great difference in the expansion and contraction and the galvanic action that is likely to take place.

100. Dimensions.—The gauge, thickness, and weight per square foot of zinc used for roofing purposes are given in Table XV.

TABLE XV

GAUGE, THICKNESS, AND WEIGHT OF ZINC ROOFING

Gauge Number	Thickness Inches	Weight Ounces per Square Foot
13	.0311	10
14	.0457	12
15	.0534	14
16	.0611	16
17	.0686	18
18	.0761	20

SLATE ROOFING

101. Slate used for roofing purposes, commonly known as *clay slate*, is obtained from an argillaceous or clayey rock of a compact and fine-grained texture. This rock is formed through the deposition of matter by the action of water, and belongs to a class geologically termed *sedimentary* rock, which split very readily into thin laminæ, or slabs, along parallel planes, called the cleavage planes—a characteristic that renders slate very valuable as a roofing material.

The cleavage planes do not run in any fixed direction with respect to their beds, but incline at various angles, from perpendicular to horizontal. The slate whose cleavage planes are almost nearly horizontal or parallel to the natural bed, is unfit as a roofing material, as the slabs will have a rough and irregular surface, which will prevent them from being fitted closely when laid.

102. Qualities of Slate.—Good slate should possess both toughness and hardness, and a very fine, but easily distinguished, grain. The slates should be tough enough to be easily punched for nailing, and should cut to standard sizes without splintering or becoming friable at the edges. They should be hard enough not to absorb much moisture, as the action of frost on the moisture will cause the edges to crumble and will also tend to enlarge the nail holes, and thus cause the slate to loosen from the roof.

The grain should run lengthwise of the slate. Veins or ribbons are objectionable markings, especially when parallel with the grain. Crystals of pyrites are sometimes found in slate, the yellow variety of which is not very injurious, but still objectionable, except in those qualities classed as second rate. Slate containing white pyrites, however, should always be rejected. The *color* of slate varies considerable, and is in no way indicative of the quality of the material. Blue, blue-black, purple, gray, green, and red are the most common tints, although cream color is occasionally, but rarely, found.

103. Qualities of slate vary with the characteristics of the rock, as just described, as do also the straightness, smoothness of surface, and uniformity of thickness of the quarried product. All qualities are obtainable in various market sizes from 6 in. × 12 in. to 24 in. × 44 in., all $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, the average being $\frac{3}{16}$ inch. Tests to determine the quality of slate are sometimes made, but cannot be relied on, although they are of value in some instances where certain characteristics are to be determined.

The *porosity* and amount of absorption may be obtained by weighing a dry slate, as delivered from the quarry, and reweighing it after soaking in water from 24 to 36 hours; the difference in weight shows the amount of water absorbed. Or a slate may be permitted to stand on edge in a shallow dish of water, the height to which the water rises in the pores being noted; if the absorption is great, the slate is not suited for roofing, as frost would tend to splinter the edges.

Slate submitted to the action of dilute sulphuric acid will, if of a proper degree of hardness, remain unchanged for several weeks; but if of soft quality, it will decompose and crumble in a few days. Powdered slate, submitted to the action of muriatic acid, will effervesce strongly when it contains carbonate of lime, and should not then be used for roofing purposes. Powdered slate submitted to a high temperature, will give off a yellow sublimate of sulphur, when it contains pyrites, and should not be used, as it is not of a durable quality.

Although the foregoing tests tend to show some of the characteristics of different qualities of slate, they are not entirely reliable in determining the value of the slate as a roof covering, for some of the hardest slates will undergo decomposition on the roof, even after passing all these preliminary tests.

A good slate should present a bright, silk-like luster, and should emit a clear, metallic ring when struck with the knuckles, showing that it is hard; if it is soft, it will have a dull, lead-like surface, and will give out a muffled sound. When cut, the edges should show a fibrous-like texture, free from splinters, and the material should not show signs of being either brittle or crumbly.

No better test of the wearing or weathering qualities can be applied than the simple and effective one of examining roofs where the slate has been in service for several years.

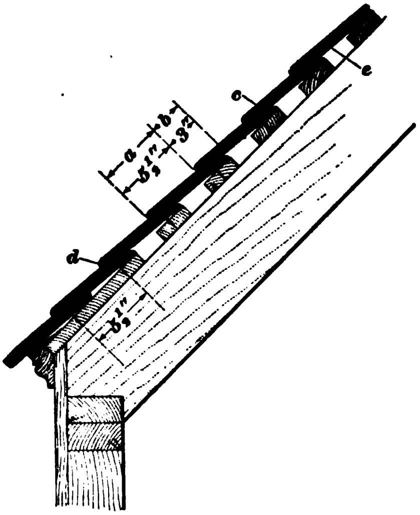


FIG. 88

104. Terms Used in Slating.—The terms applied to the different parts of roofing slate are: the *gauge*, or *weather*, which is that part of the slate which is exposed when laid, as shown at *a*, Fig. 88; the *lap*, which is the distance that each slate overlaps the second one below it, as at *b*; the *head*, or upper end of each slate, as at *c*; and the *tail*, or lower end of each slate, as at *d*. The *bed* is the under surface of each slate when laid, and the *back* is the upper surface when laid.

Rendering consists in covering the under side of the slate with haired mortar, especially when the slates are laid on battens, although it is sometimes done when the roof is boarded, by laying the slate on the mortar, which has been applied directly to the boards. Rendering prevents the wind from blowing rain or snow through the crevices when felt is not used over the boards. It is not effective when the slate is laid on lath or battens, as they are likely to settle and crack the rendering.

Shouldering consists in applying to the head of each slate, to a depth of 2 inches, a thin bed of haired mortar or slater's cement. Shouldering is resorted to only in very exposed situations.

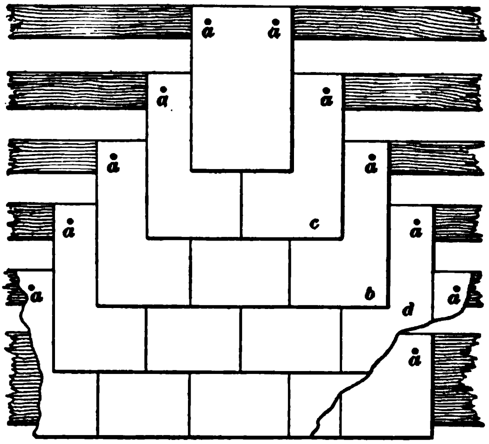


FIG. 89

Torching consists in pointing the joints between the heads and tails of the slates from the under side with haired mortar or slater's cement, and is done after the slates are laid; it is of little value, as it soon falls out, leaving the joints open.

105. Nailing.—There are two methods of nailing roofing slate: *head-nailing* and *shoulder nailing*. In **head-nailing**, which is the usual method employed, the nail holes are punched about 2 inches from the top, as at *a*, Fig. 89, and the tails of the next two courses, as *b* and *c*, lap over the nail holes. Should the first-covering slate *b* become broken, the nails are thus still protected from the weather by the lap of the second-covering slate. The objection to this method is the leverage exerted by the wind. In **shoulder nailing,** Fig. 90, holes are punched at a distance from the tail of the slate equal to a little more than the gauge plus the lap.

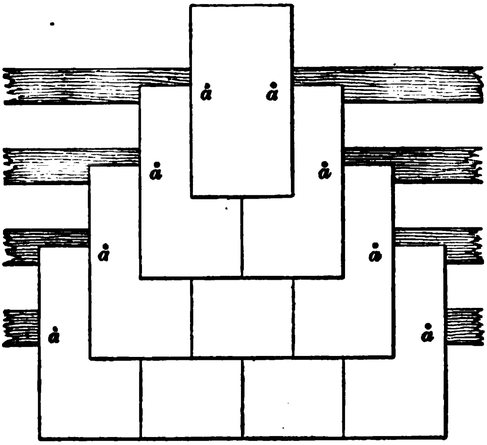


FIG. 90

106. Cut Slate.—The tail-ends of slates are sometimes cut on the corners so as to give, when laid, a semi-octagonal or triangular gauge, and when so treated are termed **cut slates.**

Cut slates tend to shed the water more rapidly than square-end slates, as their form acts as a guide, carrying the water to a point that it readily leaves, thereby clearing the roof quickly; while, with square slates, the water lodges in the joints and accumulates on the lower edge and drips off so slowly that the joints are wet when the rest of the roof is dry. In winter, the alternate freezing and thawing is likely to loosen the slates and cause the edges to crumble. A roof covered with cut slates is, however, not so strong as one covered with square slates, as much of the material is cut away.

107. Sorting and Piling Slate.—Sorting and piling slates preparatory to laying is a most important detail of the roofer's work. Slates should be piled with their edges up, the pile in no case being more than 3 feet 6 inches in height; the ends of the tiers may be held up by laying a pile of slates on the flat, while the top of the pile should be covered with slates laid flat, to keep out moisture. The slate should be sorted or selected by grades of thickness, the thin slates being piled first and the thicker ones next.

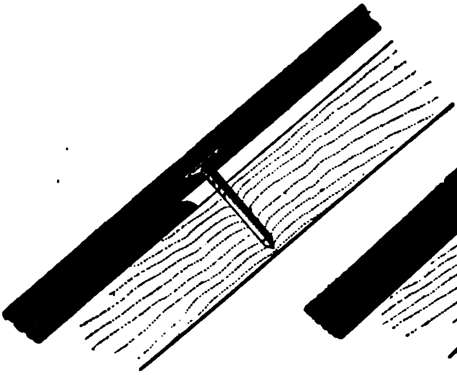


FIG. 91

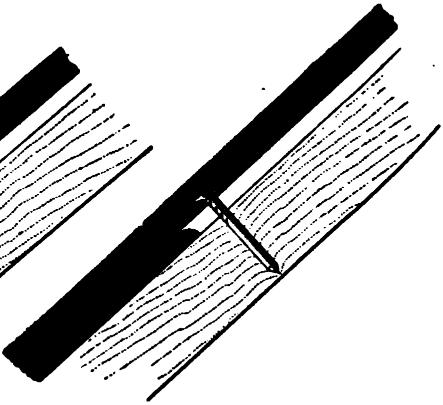


FIG. 92

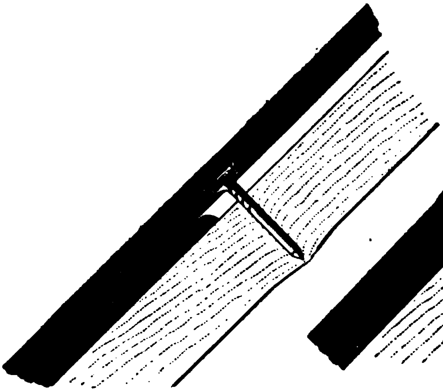


FIG. 93

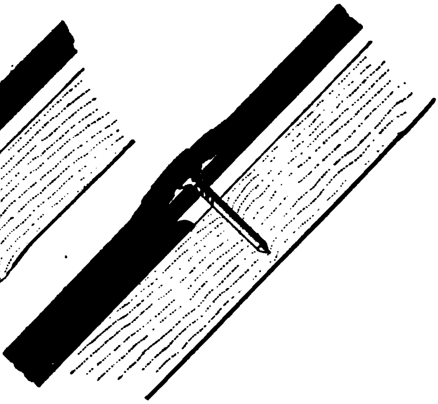


FIG. 94

Thick slates should be laid on the lower part of the roof and the thinner ones at the top.

108. **Machine-punched slates** make a better job than **hand-punched.** In Fig. 91 is shown a section through a machine-punched slate; the hole is clean cut and gives the very best result. In Fig. 92 is shown a hand-punched slate whose edge is ragged and flaked, the slate consequently being weakened. In Fig. 93 is shown another machine-punched slate, but with the nails driven too tightly. The result is as indicated. The slate has sprung to its natural position, pulling the head of the nail through, as shown, rendering it of little value for holding the slate. In Fig. 94 is shown a machine-punched slate with the nail insufficiently driven, causing the nail head to be forced through the upper slate by pressure from above.

109. **Methods of Slating.**—There are three methods of laying slate roofing: (1) on laths or battens; (2) on boards covered with felt; and, (3) a method called *half slating*, on either battens or boards. With the first method, the roof is prepared as for shingles laid on lath, as previously explained. For the second method, the best results are obtained by covering the roof with $1\frac{1}{4}'' \times 6''$ matched boards. The objection to wider sheathing boards is that they are likely to shrink, curl on the edges, and lift some of the slates, thereby giving the roof a rough, uneven appearance. If wide boards are used, however, they must be well nailed at both edges. More care in this respect is needed when the sheathing is applied to curved roofs, or round towers, in which cases the sheathing must be perfectly solid and smooth. When the sheathing is not solid, the driving of a nail is almost sure to loosen the slate that has been previously nailed, and a uniformly tight job is impossible.

The sheathing felt should be applied parallel to the eaves, if possible, but if the roof is steep it may be laid at right angles to them. In either case it is lapped 2 inches and fastened to the roof with nails having large flat heads. The tilting fillet at the eaves, valleys, gable ends, etc., the saddles and cant boards at the back of chimneys, flashings, etc., as previously described, should all be well secured to the roof boards.

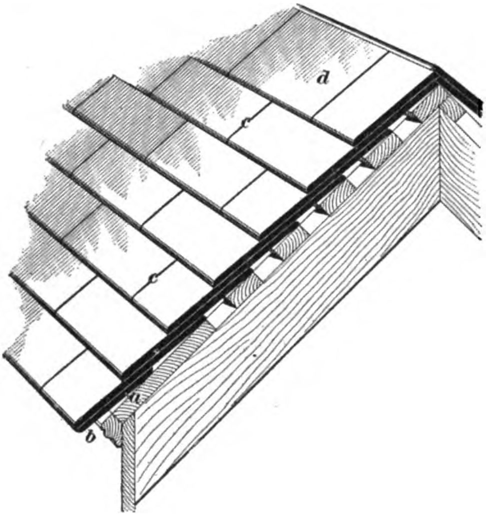


Fig. 95

In commencing to slate, the first course is laid double, the lower, or *undereaves*, course being laid with the back of the slate next to the boards; the length of the slates in this course will be equal to the gauge plus the lap, as seen at *a*, Fig. 95, and should project over the eaves or gutter edge from 1½ to 2 inches, as at *b*. All the courses must be laid with broken joints, as shown at *c*; the last course, as at *d*, is known as a *finisher*, and is put on to receive the ridge roll.

110. The third method, known as **half slating,** is generally used on cheap buildings, where economy of material is required. If laid on battens, half slating should be used only when a perfectly tight roof is not necessary; but if laid on boards covered with felt, it makes a good serviceable low-priced roof. The lower courses should be laid double, as in the other methods. The courses above this have a space between the edges of the slates equal to

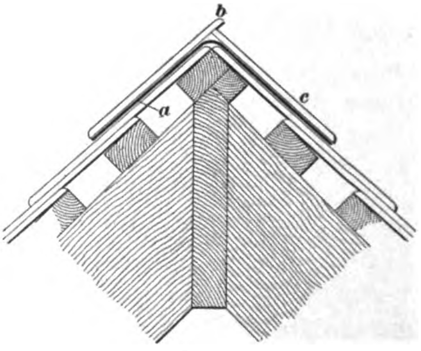


Fig. 96

one-half the width of each slate. The whole surface is thus laid, up to the ridge; the last course, or finisher, and the ridge roll being completed as for the other roofs.

111. Ridges.—The ridge on a slate roof may be finished in various ways. A method used on cheap buildings has a metal saddle flashing, as at *a*, Fig. 96, with the slate finished over it, one slate lapping over the other ½ inch, as at *b*.

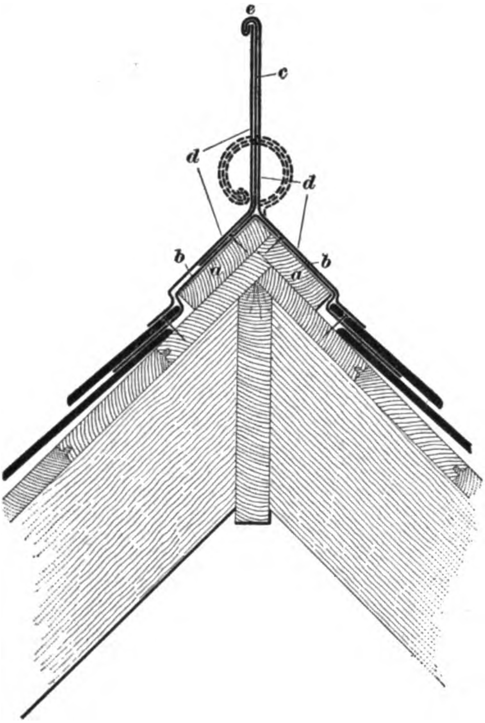


Fig. 97

The wings of the metal flashing are just equal to the length of the ridge slate *c*. The objection to this form is that the nails securing the ridge slates are driven through the metal flashing.

Another method consists in nailing to the roof boards a wooden ridge saddle or strip *a*, Fig. 97, on each side of the ridge. A saddle flashing *b* is then bent over this, with the wings extending 4 or 5 inches down the roof and under the last course of slates, which are laid up to the edge of the saddle *a*. Strips of metal *c*, 8 in. or 10 in. × 2 in., are nailed along the saddle at intervals of 16 inches, and a wing piece *d* is then laid on each side, lapping over the slate 2 or 3 inches, and is bent and shaped up to the top of the clip *c*, over which it is turned and locked, as shown at *e*. The whole is then bent and formed into a roll, as indicated by the dotted lines.

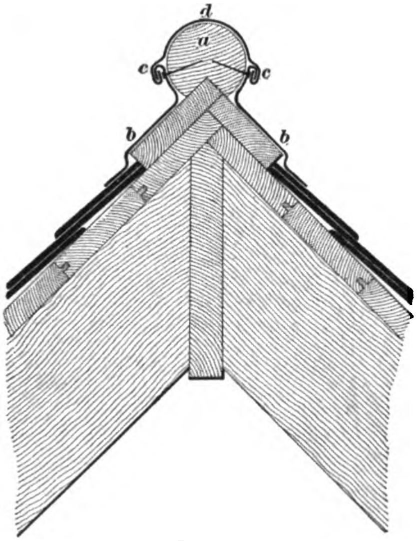


FIG. 98

Another method, much the same in principle as the one just described, is shown in Fig. 98. The metal saddle flashing over the wooden saddle is omitted, and the slate is carried up to the wooden saddle, on which is nailed a wooden roll, as shown at *a*. A wing flashing *b* is placed so as to cover each side of the ridge—overlapping the slate 2 or 3 inches—and is bent up against the roll and lock-seamed as at *c*, the flashing being secured by nailing under the lock-seam into the wooden roll; a metal roll cap *d* with lock-seam

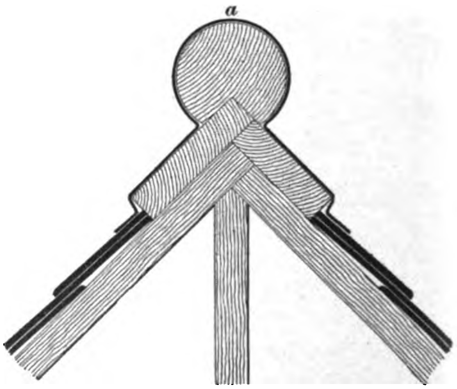


FIG. 99

edges is then slipped over the wooden roll, interlocking with the edges of the wings and thus completing the ridge. A cheaper roll is constructed as shown in Fig. 99, the roll *a* being kept in place by its natural spring.

Methods of capping with slate rolls and wings are seldom used on account of their expense, but when necessary should be constructed as shown in Fig. 100 (*a*) and (*b*). At (*a*), the wing pieces *a* are cut from solid slate; they are screwed together with brass screws *b*, and the cap *c* is placed over them. At (*b*), the wing piece *a* has the roll cut on it and laps the wing *b* on the other side. Both ridges must be set in cement, without nailing to the roof.

A good rule for proportioning the wings to the roll is as follows: With a 2-inch roll use a 5½-inch wing; with a 2½-inch roll use a 6-inch wing; and with a 3-inch roll use a 7-inch wing.

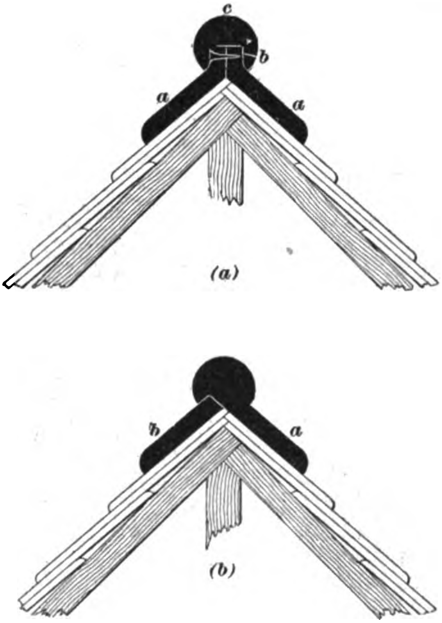


Fig. 100

112. Hips and Valleys.—Hips in slate should be finished the same as described for shingle roofs. If a roll is applied, the method shown in Fig. 99, with a short, flat wing, will serve all purposes and will give a neat finish.

Valleys may be constructed in the same manner as those described for shingle roofs, as may also the flashings around the chimneys, skylights, bulkheads, ventilators, etc.

Where a slate roof finishes against a parapet, gable, or other wall of brick or stone, there should be provided both flashings and counterflashings, the flashings to be cut in short lengths, 2 inches longer than the unexposed part of the slate, and to be laid as each course of slate is put on, as shown at *a*, Fig. 101. This flashing should have a lap on the roof equal to the width of one-half a slate, and should turn up against the wall at least 4 or 5 inches. The flashing against the wall should not be nailed, for if the roof were to settle, the flashing would lift the slate or break them. This flashing is sometimes called a "soaker." The counterflashing *b*, which covers the soaker flashing, is either let into a reglet cut 1 inch deep in the stone or stepped into the joints, as shown. This stepped counterflashing is secured at the top by wall hooks, and the joints are well pointed with elastic cement.

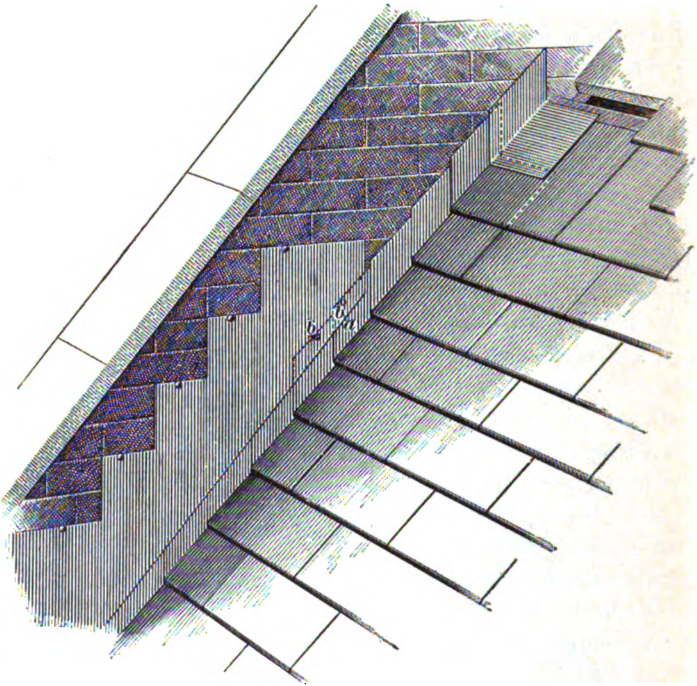


Fig. 101

113. Slating Curved Surfaces.—In slating curved surfaces, follow the directions given for shingle roofs, commencing at the lower course, with slate from 6 to 10 inches wide, and gradually reducing the size until a slate 2 inches in width is reached. This is about the smallest size that will safely cover a nail hole and keep the weather from affecting it; even with this width the upper courses should be well bedded in slater's cement (which is generally composed of paint skins and refuse lead), as should also all hips, ridges, and joints around chimneys, bulkheads, gables, and parapet walls.

114. Nails for Slating.—The nails used for slating have large flat heads, so that they may get a good hold on the surface of the slate. The proper length of a nail is twice the thickness of the slate, plus the thickness of the boarding or lathing; this length will give the full amount of hold that can be secured. The nails generally used are threepenny, which are $1\frac{1}{8}$ inches long, and fourpenny, which are $1\frac{3}{8}$ inches long.

TABLE XVI

WEIGHT OF SLATE PER SQUARE FOOT

Thickness Inches	Weight Pounds
$\frac{1}{8}$	1.82
$\frac{3}{16}$	2.73
$\frac{1}{4}$	3.64
$\frac{3}{8}$	5.46
$\frac{1}{2}$	7.28
$\frac{5}{8}$	9.06
$\frac{3}{4}$	10.87
1	14.50

115. Number of Slates Required.—Slating is calculated by the square of 100 square feet. To ascertain the number of slates of a given size required per square, subtract 3 inches from the length of the slate, multiply the remainder by the width, and divide by 2; this will be the number of square inches of roof covered by the gauge of each slate. Then divide 14,400, the number of square inches in a square, by the number of square inches covered by each slate, and the result will be the number of slates required for a square of roof.

TILE ROOFING

116. Tiles.—The clay used in the manufacture of tiles is composed of aluminum and silicic acid, forming two-thirds of its bulk, with about 10 per cent. each of water and quartz, and very small quantities of potash, titanic acid, and oxide of iron. To prepare the clay for use, it is weathered, which means exposing it to the frost or sun, then mellowed, or allowed to stand for a period, tempered by additional working of the clay, plugged, and cleared from stones. It is then ready for molding, after which it is burned in a kiln, glazed, and fired.

117. Salt-glazed vitrified tiles are subjected to intense heat, the glazing being accomplished by throwing salt on the tile in the fire, creating a vapor that unites chemically with the clay and forms a glazing that is not affected by gases, acids, or steam, and is practically indestructible.

Slip-glazed tiles are what are known as firebrick clay tile; they are very porous, and are glazed with another clay known as slip, which is applied under heat; the slip, however, being a foreign body, is liable to chip and scale off. For this reason, vitrified tile should always be used in preference to slip-glazed tile.

Tiles of good quality emit a clear, ringing sound when struck together, or with a steel tool. The gauge of tile is the same as of shingles, and refers to the exposed portion of the tile.

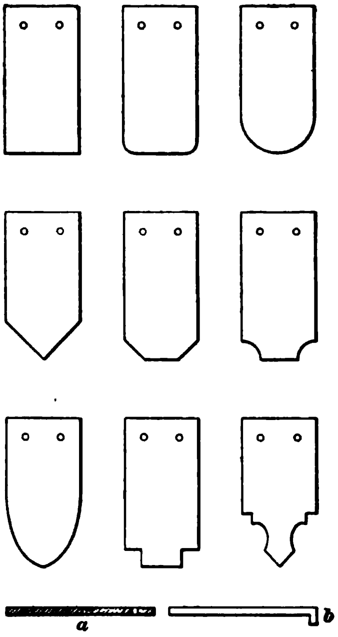


Fig. 102

118. Styles of Tile.—The styles of tile manufactured are very numerous; they are, however, generally of the interlocking pattern, and are made so that they may be laid either on boarding or on battens. The following varieties are generally used: the plain-surface tile, with the eave hips; ridge or cresting tile; and finial to suit. Shingle tile are called *square*, *round corner*, *round end*, *hexagon*, *octagon*, *scallop*, *Gothic*, *Grecian*, and *Persian*, and are shown in the order named in Fig. 102. Those used for laying on boards are flat, as at *a*, with two nail holes in the upper end; and those for hanging on lath have a rib, or lug, *b* cast on the back, in addition to the nail holes.

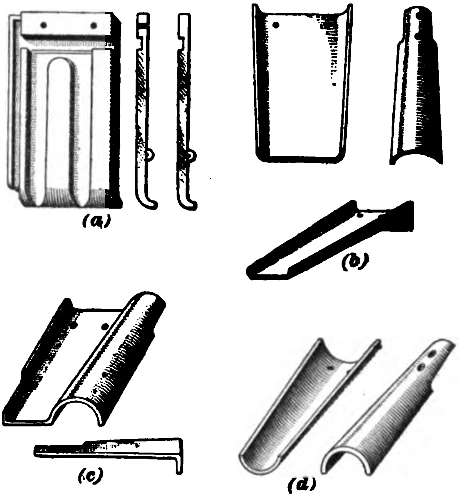


Fig. 103

The French tile shown in Fig. 103 (*a*) may be used for laying on boards or battens; the Roman, Fig. 103 (*b*), for boards or battens. The modern Spanish tile is shown at (*c*), and the old Spanish, at (*d*), Fig. 103.

In Fig. 104 (*a*) is shown the Corean or Oriental ridge tile to be used with modern Spanish tile shown at (*b*); the eave, or starter, tile is shown at (*c*). Ridge tile should be special, and when so made, the wing of the ridge takes the form of the tile at its lower edge. Eaves tile may be made with antefixa, as shown at (*d*), which enriches the appearance of

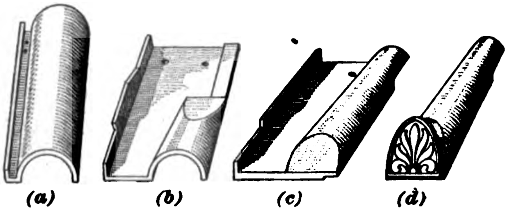


Fig. 104

the eaves and take the place of the plain finish. These tiles are sometimes inserted at intervals on the roof to act as a snow guard.

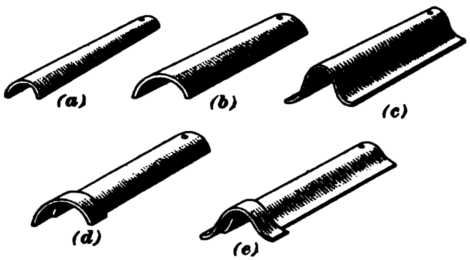


FIG. 105

Hip-roll tile, shown in Fig. 105 (*a*), (*b*), and (*c*), are overlapped 3 inches when laid, while the *roll tiles* shown at (*d*) and (*e*) have lap joints cast on them; these tiles are secured to the wooden hip roll by nails at the lap. Plain overlapping cresting, or ridging, is shown in Fig. 106 (*a*), and consists of rolls and covers with a plain cresting cast on the cover tile. In Fig. 106 (*b*) and (*c*) is shown two styles of lap-joint ridge cresting.

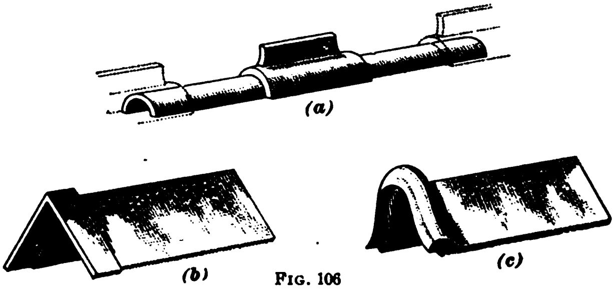


FIG. 106

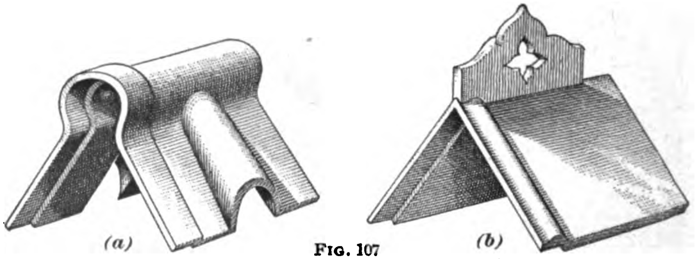


FIG. 107

In Fig. 107 (*a*) is shown a ridge roll made to receive the tile, and also having a lap joint, and at (*b*) is shown an ornamental ridge cresting with lap joint.

In Fig. 108 (*a*) and (*b*) is shown two styles of gable finials; in (*c*) and (*d*) are two hip finials—one with plain wings and the other with wings made to receive the hip-roll tile, the center tile of the front slope, and the first continuous row of tile of the side pitches.

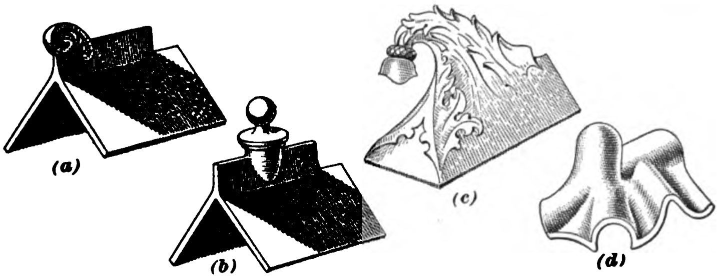


FIG. 108

119. Tile Dimensions.—The thickness as well as the length and breadth of tile varies. They run from $\frac{3}{8}$ to $\frac{3}{4}$ inch in thickness, from 3 to 9 inches in breadth, and from 10 to 16 inches in length; the $\frac{3}{8}$-inch thickness is generally used.

120. Methods of Tiling.—There are four methods of fastening tiles to the boards or battens: by hanging with oak pegs, as shown in Fig. 109 (*a*); by nails, as in (*b*); with a rib or lug and nails as in (*c*); and, as shown in (*d*), with a rib or lug molded in the under side of the tile into which a wire is hooked, and nailed to the lath or batten.

Rendering is used with flat tiles, and torching and shouldering with all tiles in very exposed places, or on flat-pitched roofs; under ordinary conditions, however, these processes are not necessary. When used, they should be applied in the manner described for slate roofing.

The roof should be prepared to receive the tile by covering the rafters with either boards or battens, depending on the kind of tile to be used. If boards are required, they should be from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches thick and 6 or 8 inches wide, tongued and grooved, and should be laid diagonally, being well nailed at each bearing and at the edges to prevent curling.

Tilting fillets should be nailed at the eaves, valleys, gutters, gables, etc., as described for shingle roofing. When battens or laths are used, especial care must be taken to see that the laths are spaced the proper distance apart to receive the tile to be used, and that the laths are horizontal to the eaves, so that the vertical joint of the tile will be at right angles to the eaves. If the tiles are laid on boards, the roof should be covered with two thicknesses of single-ply or one thickness of double-ply roofing felt, and after the felt has been applied, the gutter and other flashings should be constructed—as described under the heading Shingle Roofing—and put in place.

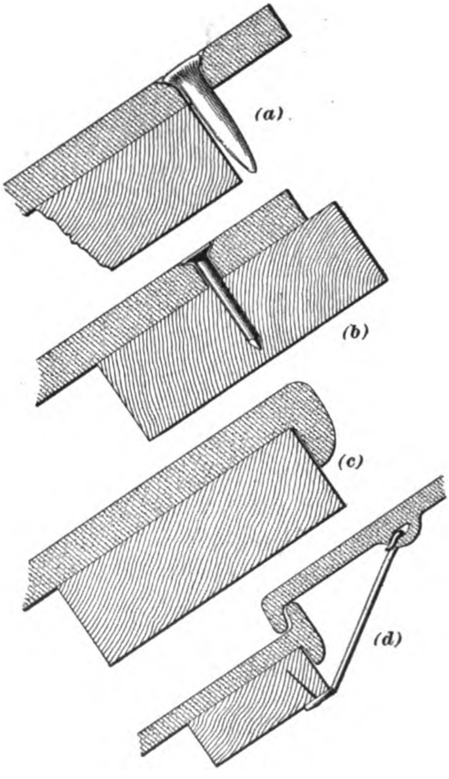


FIG. 109

121. The gutter flashing should be of 16-ounce copper, well nailed with copper nails over the eaves tilting fillet, and locked to the gutter proper with a lock-seam unsoldered; or it may be turned down over the upstand of the gutter. The first method is used for a gutter nearly level with the eaves, and the second, when the gutter is slightly below the eaves.

For valley gutters, 14- or 16-ounce copper should be used in 6-foot lengths, locked and soldered together in lengths corresponding to the length of the valley. It is then formed, and nailed with copper nails to the roof back of the valley tilting fillets, or held in place with copper screws. The valleys should be 20 or 24 inches wide.

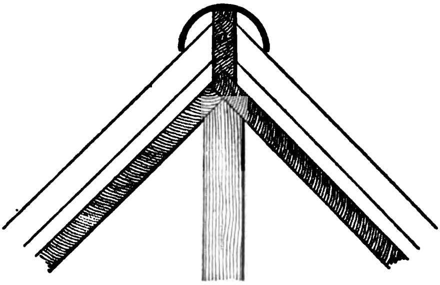


FIG. 110

The hips do not require flashing. A wooden hip fillet *a*, Fig. 110, of sufficient height to receive the tile and give it bearing, is attached to the sheathing, and the hip tile is fastened to this fillet.

Where a roof comes against parapet, or gable, walls, the junction should be flashed with 14- or 16-ounce copper, nailed to the roof back of the tilting fillet. The flashing should be allowed to lap on the roof a distance equal to the width of a tile over the fillet, and should be carried up against the wall

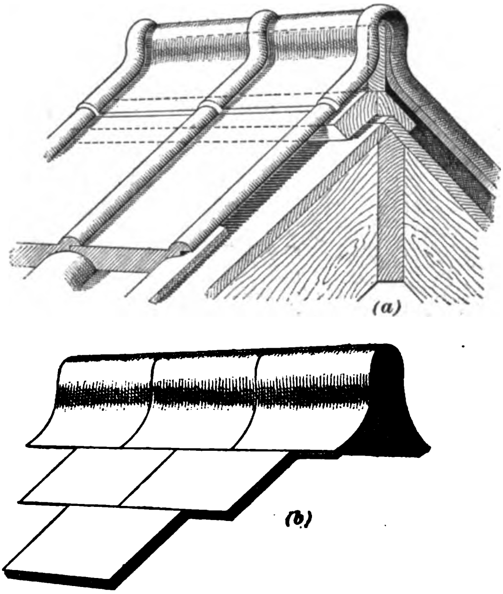


FIG. 111

at least 7 inches. From the under side of the wall coping, or from a reglet cut in the wall, a lead apron should overlap the copper upstand at least 3 inches, and should be secured to the wall with lead plugs.

122. The ridge does not require flashing, but should be prepared to receive the tile ridge roll in the same manner as that shown for hips.

Where the tile comes against the wooden hip roll, they should be cut off to the proper angle and bedded in elastic cement. The valley tile should be made at the works, to conform with the proper angle of the roof, and should have closed ends. Around all chimneys and other openings in the roof, as well as at the finishing course along the ridge, the tile should be well bedded in slater's cement.

Where the ridge tiles have a very deep wing, they should be specially cast with a lap joint, and should be laid in courses the same as the tile shown in Fig. 111 (*a*). They are sometimes built up of flat pieces of tile, as in Fig. 111 (*b*), with rabbeted joints, and laid with the vertical joints broken; the former tile, however, is preferable.

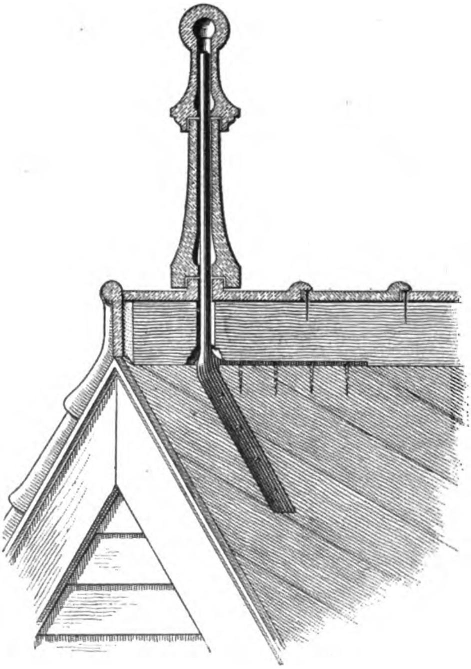


FIG. 112

123. Tile Finials.—Very heavy hip or gable finials should be well braced with brass or galvanized-iron rods, and the sections of terra-cotta finials should be securely wired or

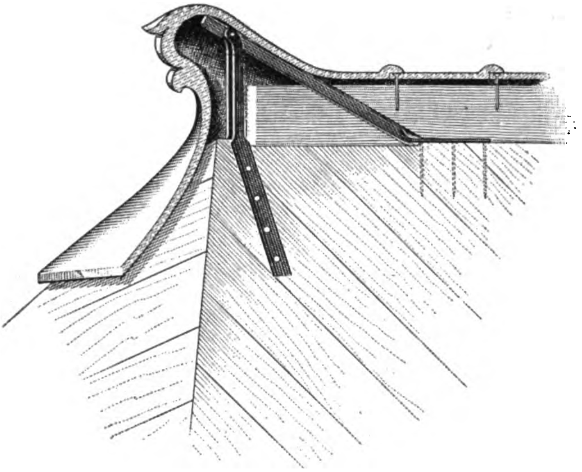


FIG. 113

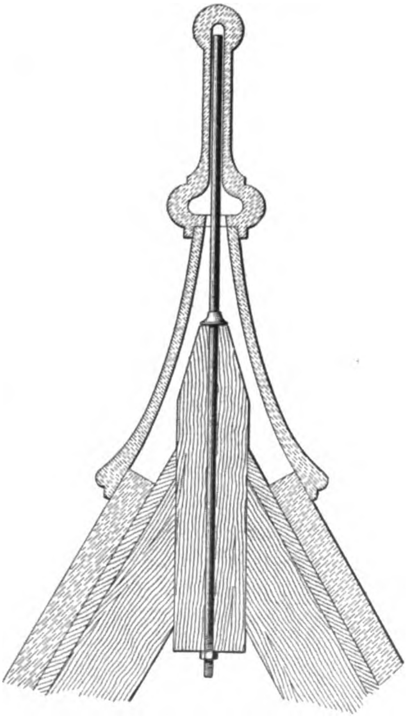


FIG. 114

anchored to these braces, and well cemented. If necessary, a wooden cradle should be built on the roof to receive the finials.

The finials on hips and ridge ends may be secured with a tripod form of brace. For a vertical finial, the tripod may be made and secured to the roof as shown in Fig. 112, the ends of the iron being held in place with brass or galvanized-iron screws. For an overhanging hip finial, the brace may be constructed as in Fig. 113, the top of the rod being carried to the ridge of the finial. Where the finial is on the apex of a tower, the brace may be constructed with a galvanized-iron pipe of dimensions to suit the size and shape of the finial, and stiff enough to resist the wind pressure. The construction of such a brace is shown in Fig. 114.

124. Use of Ornamental Roofing Tile.—A roof may be covered entirely with ornamental roofing tile, or they may be used at intervals among flat tile to break the monotonous appearance of the roof. When mixed with the plain tile, they may be arranged in pattern or figure shape, but care must be taken to retain uniformity of color in both kinds.

125. Conical Roofs.—The tiles for conical roofs must be made to suit the requirements of each case. It is, however, possible, with some varieties of tile, to use a uniform size for four or five courses, or tiers, and a smaller one for the next four or five courses, and so on until the base of the finial is reached.

Shingle tile may be cut on the sides so as to make them conform with the radial lines from the apex, in the same manner as was described for slate and shingles. If, however, the butt of the tile is formed with a pattern, this method cannot be used, and special tile must be made. The eave tiles and the upper courses adjacent to the apex should be well bedded in slater's cement.

GLASS ROOFS

126. Glass as a roof covering may be used to great advantage for inside halls and passageways, picture galleries, and extensions where ordinary windows cannot be inserted, for dome lights, greenhouses, railroad stations, etc. Wherever used, the construction should be what is known as "puttyless," that is, no putty should be used in bedding the glass whether the bars are of metal or of wood.

127. Skylight Frames.—The frame for all house work except greenhouses, and even the better class of these, should be, preferably, of copper, galvanized iron, or zinc.

The construction of these frames or bars consists of a gutter composed of three pieces, the *flange*, the *gutter*, and the *cap*. In Fig. 115 is shown the general construction of the complete bar. The center member *a* has a straight web about 1¼ inches high, with a circular tube ⅝ inch in diameter formed at its lower edge. The gutter or outer member *b* consists of one piece, bent at the center, capped over the web or centerpiece, and having the edges formed into ¾-inch tubes that rest on the tube of the web member. The upper flanges of these tubes support the glass. The cleats, or holdfasts, *c*, which bind the cap, are secured by the rivets that join the web and gutter members, and the cap *d* is made of one piece, in the shape of an inverted **V**, with a simple lock on the two lower edges to receive the flashings. The flashings *e* are strips of lead, locked at the upper edge into the

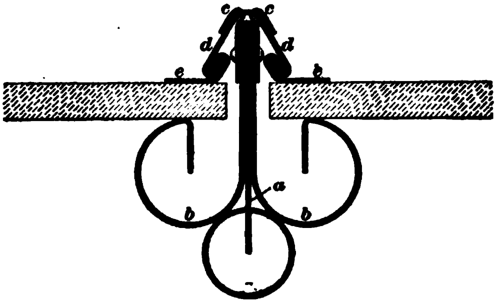


FIG. 115

cap, and bent down close to the glass, in order to make a water-tight connection. The cap is secured to the bar by passing the clips through a slit cut in its apex, the ends being turned down and soldered and wiped to the cap. In some cases, the ends are simply turned down over the cap.

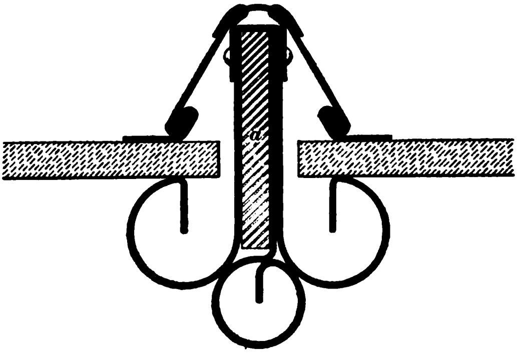


Fig. 116

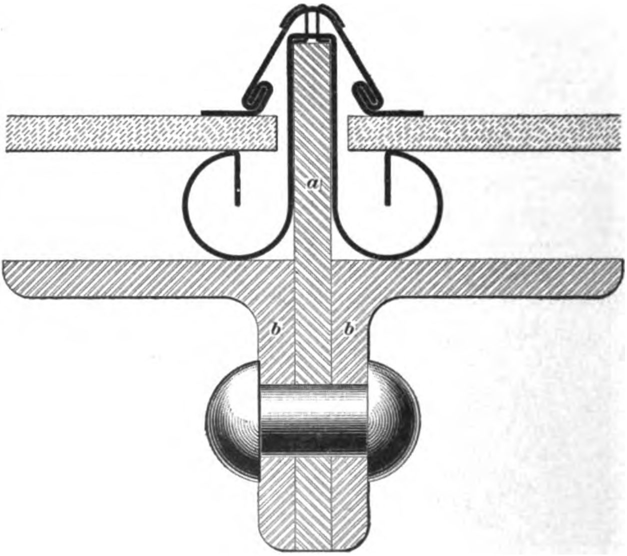


Fig. 117

This system of construction may be applied to the whole or a part of a roof, and also to skylights. It may also be used in conjunction with iron or wood framing for the roof proper.

For small skylights, where an under support may be dispensed with, the light bar, as shown in Fig. 115, may be used. For larger openings, a heavy iron bar incased with sheet metal, as shown at *a*, Fig. 116, will give the requisite strength.

Fig. 117 shows an iron rafter for a roof; it is composed of a web-plate *a*, $3\frac{1}{2}$ in. × $\frac{1}{4}$ in., and two angles *b*, *b*, 2 in. × 2 in. × $\frac{1}{4}$ in. bolted together. The portion *a* projects beyond the flanges of the angles and a gutter is formed over it with caps, etc., as in Figs. 115 and 116.

The tubular construction imparts strength and rigidity and provides for the expansion of the metal and glass. Provision is also made for condensation, as all the bars, vertical and horizontal, act as branch gutters, which are connected to a main gutter.

128. Skylight Glass.—The glass may be from $\frac{3}{16}$ to $\frac{3}{8}$ inch thick and of any pattern. For plain work, ribbed or hammered glass may be used, the rough surface being placed on the outside. The use of a minimum thickness of glass should, for two reasons, receive consideration: first, the cost of repairs, and, second, the dead load to be supported. The size and strength of the rafters and purlins supporting the ribs should be regulated by the weight of the glass, wind pressure, and snow load.

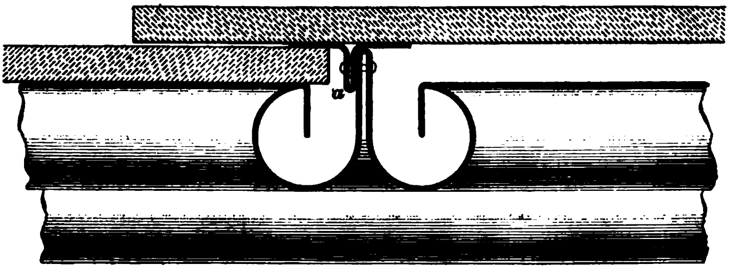


FIG. 118

129. Methods of Construction.—The horizontal lap joint of the glass, as shown in Fig. 118, is of the same construction as the gutter proper, but has a lead fillet *a*, which acts as a cushion and takes up any unevenness of the glass. The lower glass rests on the tube, and the upper on the lead cushion on the top of the rib. The glass should overlap from 1 inch to $2\frac{1}{2}$ inches, according to the pitch. At the end of each light of glass is a stop, or holdfast, made and placed as shown at *a*, Fig. 119. These stops are placed on each side of the vertical ribs, and are fastened to the flanges with small screw bolts about $\frac{1}{8}$ or $\frac{3}{32}$ inch diameter. The slot *b* in the flange, shown by dotted lines, is cut vertically and is about three times as long as the

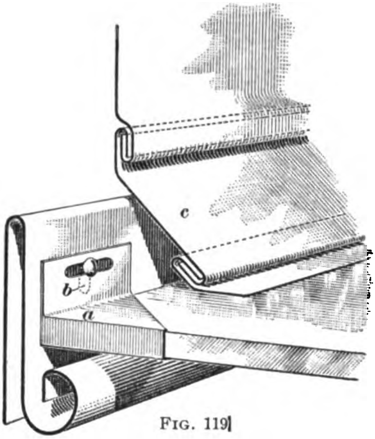


FIG. 119

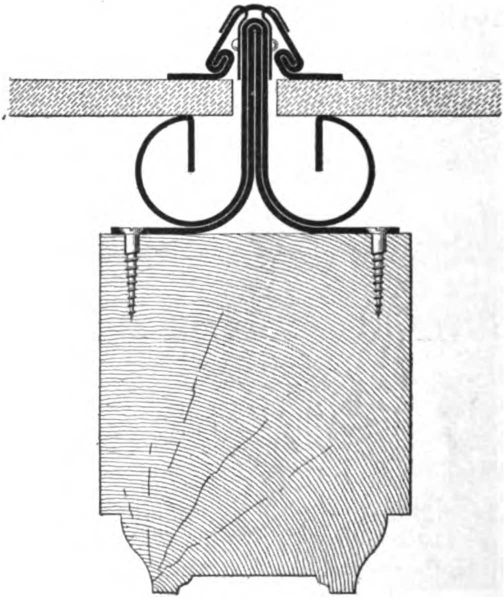


FIG. 120

diameter of the bolt. The slot in the stop, or holdfast, is cut horizontally and is a trifle longer than the other. These slots provide for adjustment and for any movement that may take place by settlement, and expansion and contraction.

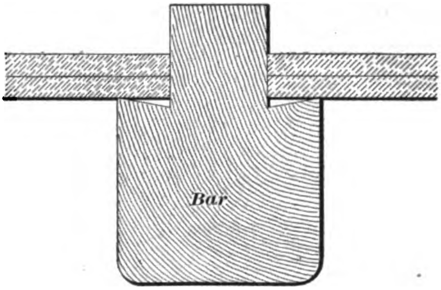


FIG. 121

The ribs that come against parapet, fire-, or other walls are similar to those shown in Fig. 119. The cap piece *c* is extended and formed into a flashing; it is let into a reglet, and may be covered with a counterflashing.

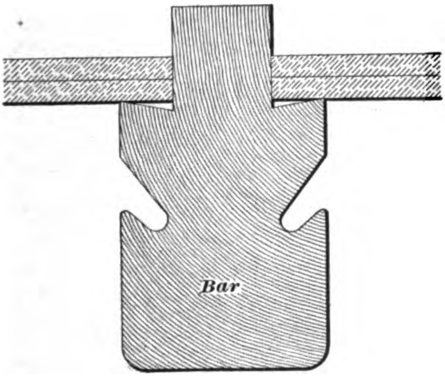


FIG. 122

When the construction to which the glass is applied is of wood, the flange piece is omitted, and the gutter piece rests on, and is secured to, the woodwork, as shown in Fig. 120.

130. There are other methods of construction, based on the same principles, varying in detail to meet the different conditions. For the roofs of greenhouses, etc., where wood construction is used,

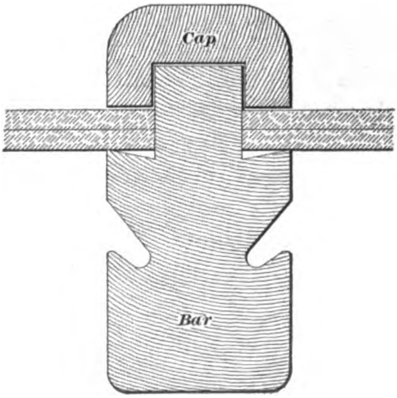


FIG. 123

the durability of the wood should be considered. It has been found that cypress gives better results than any other material. The sash bars may be made, as shown in Fig. 121. The rabbets are ⅝ inch deep, allowing for the two thicknesses of double-thick glass at the lap, and also for the nailing. The rabbet is formed with a slight bevel, thus forming a channel, which carries away any moisture that may enter. The end or gable bars must also be rabbeted, for the roof glass; and where there is a glass gable, these bars must also be rabbeted, to receive the vertical glass.

In Fig. 122 is shown a rafter bar with grooves run in the sides, to take off condensation; and in Fig. 123, a similar bar fitted with a cap.

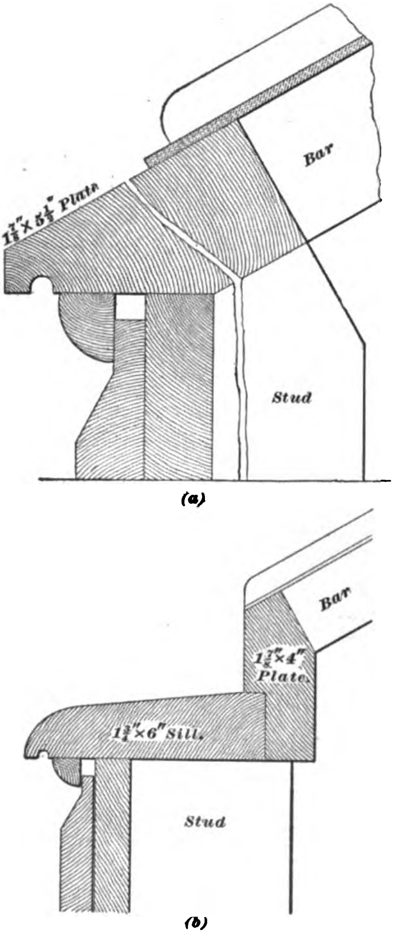


Fig. 124

131. There are several methods of constructing the plates into which the bars are framed. In Fig. 124 (*a*) is shown a plate made of 1⅞″ × 5½″ material, beveled and throated to form a drip. In Fig. 124 (*b*) is shown a different construction, in which the plate piece is 1⅞ in. × 4 in., and the sill, 1¾ in. × 6 in. The plate is beveled on the top to receive the bar, and rabbeted on the outside to receive the sill. The sill is beveled to allow the water to flow off, and throated to form a drip. In Fig. 125 (*a*) is shown a plate and gutter, the inside or plate having the same construction as Fig. 124 (*b*). If there are two pitches coming together between two ranges of roof, the construction may be as in Fig. 125 (*b*). Gutters in a roof, however, should be avoided as much as possible.

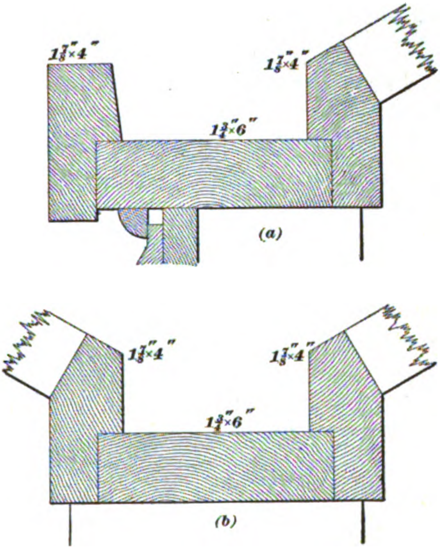


FIG. 125

132. At the ridge, there may be either a single or a double row of ventilators. In Fig. 126 (*a*) is shown a three-piece ridge, made up of a ridge piece, a shoulder cleat, and a cap. The ridge piece is 1¾ in. × 4½ in.; the shoulder cleat, ⅞ in. × 2¼ in., and the cap, 1⅜ in. × 2¾ in., rabbeted to receive the ventilator sash. This ridge is made for a double row of ventilators; if used for a single row, it should be rabbeted on one side for the glass, as indicated by the dotted lines at *c*.

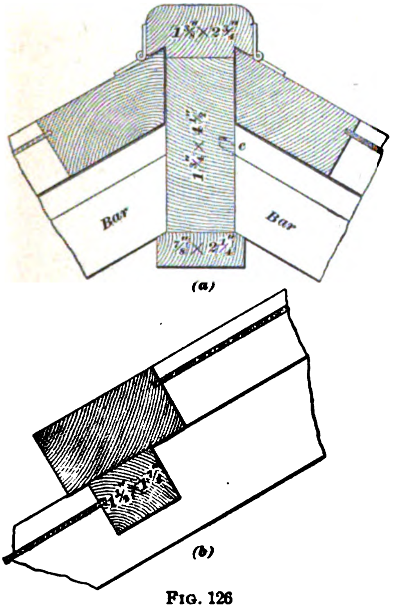


FIG. 126

The ventilators should be hinged to the ridge, close against the bars, and a header should be inserted as shown in Fig. 126 (*b*). The header may be rabbeted or grooved to receive the glass. Where the bars are more than 8 feet in length, they should be supported by purlins.

In glazing the sash, the glass is laid from the bottom up, the sheets lapping one another from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches. The lap is regulated by the pitch, which, in any case, should not be less than 20°.

STONE ROOFS

133. Construction of Stone Roofs.—Stone roofs are not much used at the present time, except for covering small vestibules, porches, turrets, towers, and monumental

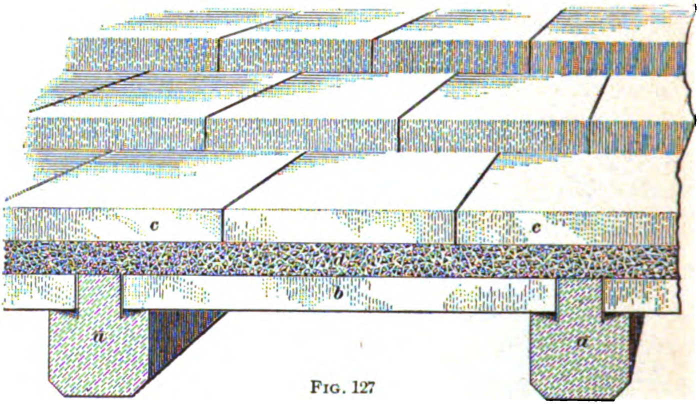


FIG. 127

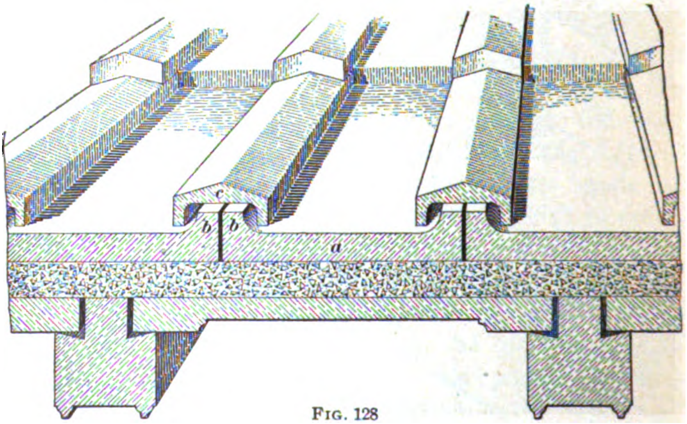


FIG. 128

buildings. They may be flat or pitched. Large slabs are used for flat roofs, and small ones for pitched roofs. They may be laid either with lap or butt joints on a filling resting on the vaulting beneath. For towers and spires, the stone is laid in tiers, either with or without a lap joint.

134. In Fig. 127 is shown the construction of a flat roof, which may be applied either to vaulting or stone purlins, the latter being shown. The purlins *a* are rabbeted to receive the ceiling slabs *b*, and the roof slabs *c* are laid and bedded in cement concrete *d*.

The Greeks and the Romans used this same method of supporting and laying the roof slab, with this difference: the slabs were cut, as shown at *a*, Fig. 128, so that they formed a channel with fillets *b* on each side, and the joint was covered with a cap *c*.

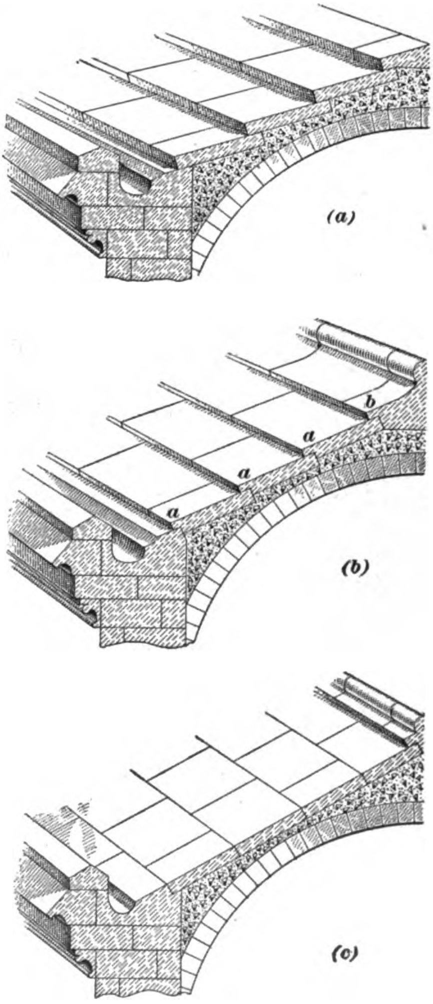


FIG. 129

For pitched roofs, ashlar slabs are used. These slabs are laid, as shown in Fig. 129 (*a*), in the same manner as shingles with broken joints; the slabs are bedded or laid in cement on the filling over the vault.

Fig. 129 (*b*) shows a better construction. The slabs are cut with a rabbet and a lap joint *a*; the cap, or ridge, stone is made with a rabbet and a lap joint *b* on each side at the edge of the wing, the same as the lower edge of the slabs. The advantages gained by the use of the rabbet and the lap joint are, that the stones, if they should work loose, cannot slip from the roof as they would if laid with a simple lap, and that there is no open vertical joint for the passage of water.

The plain butt-joint roof is shown in Fig. 129 (*c*). The gutters are cut out of a single stone, as at *a*, Fig. 130, the roof slab overlapping it. The water is carried from the gutter through a channel *b*, cut in a stone extending the full width of the wall, as shown, and discharges into the leader head *c*.

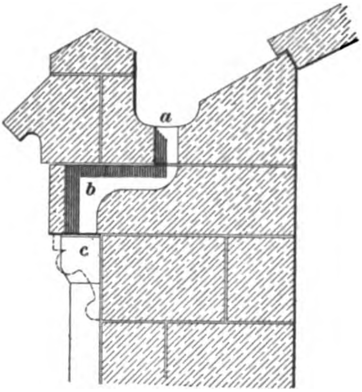


FIG. 130

135. For turrets, towers, and spires, a roof, when built of stone, is complete without the interposition of framing. In Fig. 131 (*a*) are shown a one-half elevation and a one-half section of a smooth, flush-faced, conical roof; the beds of the stone are kept level as in regular walling, while the vertical joints radiate from the center of the plan, as shown at (*b*), and bonding as indicated by the dotted lines. The outer surface of the stones used for such roofs may advance, giving the suggestion of a lap only, as at (*c*); or they may be rabbeted and lapped, as at (*d*). The terminal, cap, or finial should commence at a point where the roof stones become too small to look well, as at *e*, and should be, preferably, of one piece of stone.

136. Concrete Roofs.—Roofs are often made of reinforced concrete in the same manner as reinforced-concrete floors, which has been explained in *Concrete Construction*. As they have less load to carry than the floors, they can usually be made lighter, although it is not advisable to reduce the thickness below 3 inches. The concrete should be made quite porous to absorb any moisture that arises from the building on the inside and would otherwise be liable to cause sweating. On top of this concrete is placed a waterproof covering such as tar and gravel, or a 1-inch layer of asphalt. Sometimes a rich cement mortar is employed to make the waterproof covering, but unless laid with the utmost care, it is liable to crack. Perhaps one of the best and cheapest ways of waterproofing a concrete roof is to paint the top with Toch Brothers' R. I. W. paint. To protect this paint, a 1-inch layer of cement mortar is placed on top, made of one part cement and two parts sand, or one part cement and two and one-half parts sand.

On account of the changes of temperature, due to exposure to the weather, a reinforced-concrete roof is more liable to crack than a reinforced-concrete floor. Therefore, it should be put in place with the utmost care, and the metal reinforcement should be so placed as to prevent shrinkage cracks in all directions.

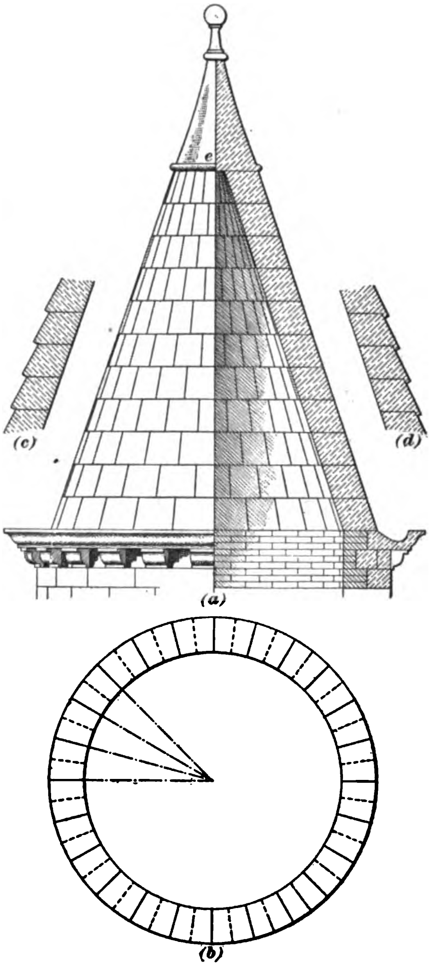


FIG. 131

137. Concrete Shingles.—A style of roofing that has been on the market but a few years is **concrete shingles**, as they are called, although in fact they are more like slates than shingles. The Keasbey & Matteson Company, at Amber, Pennsylvania, makes a shingle out of asbestos fiber and cement. These shingles are about the thickness and weight of slates, but are many times as strong. They present a smooth appearance and may be had in gray, red, and slate color. They are smooth and remarkably tough and will last for many years. They can be sawed like wood and are nailed in place with sharp-pointed nails.

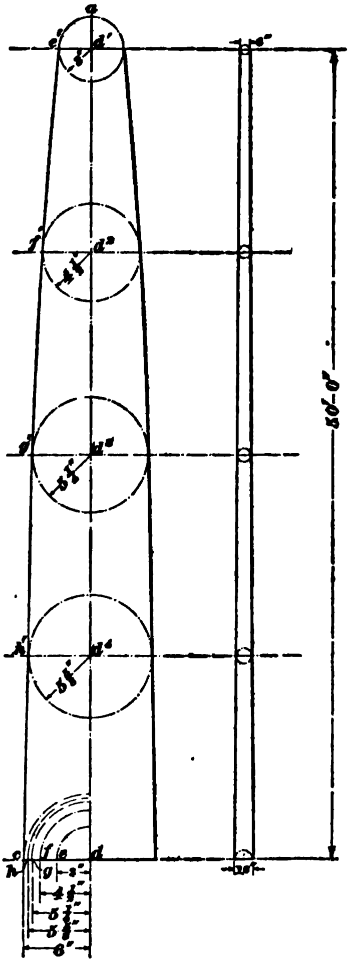


FIG. 132

FLAGPOLES

138. Correct Form.—The curve, taper, or entasis of a flagpole may be developed by the following method: The diameter at the base where it emerges from the roof should be about one-fiftieth of the height, and the diameter at the top, or head, should equal one-half the lower diameter. Assume a flagstaff 50 feet, or 600 inches, long; its diameter would be one-fiftieth of this height, or 12 inches, while the diameter at the head would be 6 inches.

To obtain the entasis, draw a center line *a d* through the pole, as shown in Fig. 132. Divide the lower half of the diameter cd as follows: From d mark a point equal to one-fourth of the lower diameter, as de; divide the remaining distance ec into two equal parts, as at f, and divide the distance cf into two equal parts, as at g, and again divide cg into two equal parts, as at h. Divide the vertical height of the shaft into four equal parts by horizontal lines; transfer the distance de to $d'e'$; df to d^2f'; dg to d^3g'; and dh to d^4h'; then through the points marked, draw the curved outline.

SNOW GUARDS

139. Use and Installation.—Snow guards made in various forms are used on all kinds of roofs to prevent the snow from sliding down into the gutters, thus clogging them and causing the water to overflow outside of the building. Where snow accumulates and freezes in a gutter, it is likely to form a dam that will cause water to back up under the slate, tile, or shingles, as the case may be, and eventually find its way into the interior of the house. Snow guards also prevent the dislodgment of large quantities of snow, which may cause injury to persons in the vicinity, as well as to ornamental shrubbery.

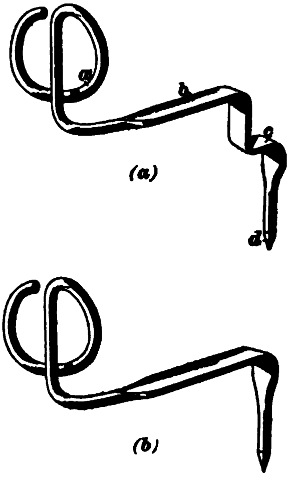


FIG. 133

140. The guard generally used is made in four styles, and is constructed of galvanized-iron or copper wire. In Fig. 133 (a) is shown a guard used with convex tiles. The loop a acts as the snow stop and stands above the tile about 2 inches; the shank b is of sufficient length to extend well back on the tile, and is made flat so that it presents the least thickness at the tile lap; the end is turned down and out and is kept flat at c, to give a driving surface over the nail point d, and to raise the guard to the height of the tile.

In Fig. 133 (*b*) is shown a guard made for flat or concave tiles. The loop and shank are the same as at (*a*), and the nail point is turned down without forming a knee, because the tiles do not stand more than $\frac{3}{8}$ inch above the roof.

In Fig. 134 (*a*) is shown a guard used for metal roofs with lock-seams. It is secured to the roof under the lock by a galvanized-iron nail driven through the loop.

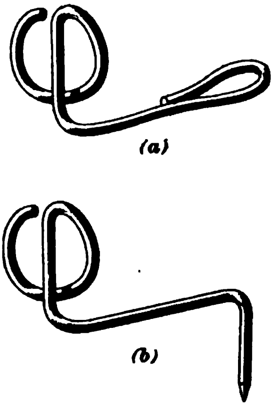


Fig. 134

In Fig. 134 (*b*) is shown a guard used for slate or shingle roofs. This guard is set between the edge joints of the slates or shingles, and the nail point is driven into the roof boards. Should this form of guard be bent down by the weight of snow and ice, it may be readily pressed back into its proper position without breaking.

Guards are also manufactured of cast iron, but, being clumsy, they are not to be recommended.

Guard-rails are also clumsy and unsightly; they gather the snow in a drift, which dams up the water, with the result already mentioned. On the other hand, wire snow guards placed all over the roof are almost invisible, and hold the snow until it melts and disappears.

SHEET-METAL WORK

USES OF SHEET METAL

1. The greater part of sheet-metal work used in building construction is employed for the following purposes:

1. For covering and flashing roofs and their intersections so that the roofs may conveniently be made water-tight.

2. For wall covering and the formation of columns, cornices, balustrades, and string and molded courses. In some cases, the entire outer surface of the walls of a building is covered with sheet metal, the material being made to resemble masonry or brickwork, an effect produced at low cost. Frame buildings may also be covered with sheet metal in order to render them less liable to fire from adjacent structures.

3. In forming gutters, valleys, or other water channels that are graded down to certain points of outlet, so that the rain that falls on the roof may be conveniently drained away, thus preventing the roof water from being shed on the ground around the building.

4. For conductor pipes, sometimes called leader pipes, which are commonly secured against the outside walls of a building to connect the lowest points of the roof gutters with an underground drainage system, or simply to a drainage above the surface of the ground, so that the roof water may flow freely away from the gutter.

5. For covering domes and lanterns, and in forming crestings and finials.

6. For interior decorations, such as the covering of walls and ceilings where first cost is an important factor; or, for

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the covering or formation of the inside trim, doors, windows, casings, etc.

7. For flues and other conduits commonly employed for purposes of ventilation.

While there are other positions and features where sheet metal may be employed, a thorough knowledge of the foregoing should enable any one to reason out and solve any special problem that may present itself.

EXTERIOR SHEET-METAL WORK

INTRODUCTION

2. The general subject of sheet-metal work for roof coverings, flashings, etc., is treated in *Roofing*, consequently, this portion of the subject will not be considered in this Section.

The kind and class of exterior sheet-metal work required will of course depend on the character and purpose of the building. Mills, factories, workshops, warehouses, etc. are often covered with galvanized sheet iron in the plainest possible manner, with no pretensions to artistic treatment, while store and office fronts are often covered with sheet metal bent and formed into elaborate moldings, or pressed and stamped into ornamental details, which are grouped so as to form decorative features.

3. Generally speaking, sheet-metal coverings for buildings are imitations of brickwork or masonry, and when properly arranged and attached to a good solid backing and carefully painted, they make, for some time, successful deceptions.

Sheet-metal fronts and other wall coverings are employed only when the desire for ornamentation exceeds the owner's willingness or capability to pay for the genuine article. From a speculative point of view, they may be paying investments, provided that the metal is protected against corrosion; but from an architectural or engineering standpoint they are utter failures.

WALL COVERINGS

4. Wall coverings may be classed as plain and ornamental. Plain wall coverings are used chiefly on buildings intended for manufacturing purposes and for such structures as are erected for temporary use; while ornamental coverings are generally used on the fronts of cheap city buildings, such as warehouses, stores, theater fronts, etc.

5. The sheet metal employed for wall coverings is usually galvanized sheet iron or steel, the sheets being either *plain*, *crimped*, or *corrugated.*

Plain sheet iron is seldom used except for the most ordinary work, where appearance is not at all considered. The sheets are simply nailed to a backing of matched lining or ordinary sheathing, the object usually being to prevent the building from readily becoming ignited, should an adjacent building be on fire.

The chief objection to plain sheet-iron siding is that the metal will bulge and become distorted in many ways, until the whole side of the building will actually appear to be covered with large blisters.

6. Crimped sheet iron is superior to plain sheet iron for covering large flat surfaces, because the crimping helps to prevent the sheets from bulging, and thus, to a certain extent, avoids the blistered appearance so pronounced on plain sheet-iron siding. A clipping of crimped sheet metal is shown in Fig. 1. The sheet is crimped by being passed through ribbed or roughened rollers, which give it the appearance of being slightly corrugated. Crimped metal, however, differs from corrugated metal in that sheets of the former, after treatment, are practically as long as they were before the process; while in corrugating, the sheet is shortened. The crimps are usually made across the sheet, while corrugations are run lengthwise.

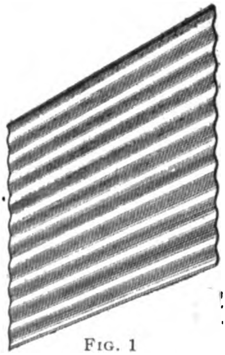


FIG. 1

Crimped sheets may be nailed to furring strips, or to studs or posts set at from 12 to 16 inches between centers, provided that the grooves run at right angles to the strips or studs. Thus, if furring strips were nailed on the studding, the grooves would be vertical; but if the sheets were nailed directly on the studding, the grooves would be horizontal. It is best, however, in every case to provide a solid flat backing for crimped sheet-metal work.

7. Corrugated sheet iron is preferable for siding where there is an extensive, unbroken surface. The corrugations not only strengthen the sheets, and thus enable them to be attached to furring strips as far apart as 4 feet, but they also relieve, by the play of light and shade, the monotony incident to a flat surface.

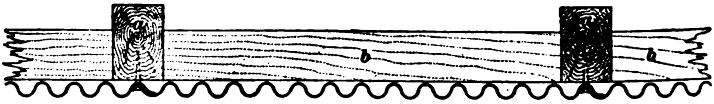


FIG. 2

Corrugated sheet iron should always be fastened with the corrugations running vertically, not so much for appearance as to obtain a perfectly water-tight siding with ordinary lap joints. Fig. 2 shows the method of forming vertical joints. The corrugations are simply lapped and the two sheets are nailed to the posts, or studs, *a*, *a* with flathead, galvanized-iron nails, as shown in the illustration. The top edge of each sheet is nailed to cross-pieces—sometimes called "nailers"—*b*, *b* that are spiked or framed in between the posts. The horizontal joints of the sheets are lapped as shown in Fig. 3; cleats are riveted on as shown at *a*, to bind the lower end of the sheet so as to make a close joint and also allow for

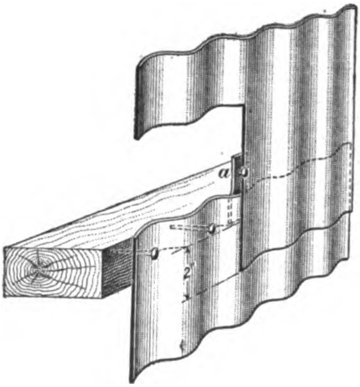


FIG. 3

expansion and contraction of the sheets. The top sheet should lap over the nails at least 2 inches.

Corrugated-iron sheets are often fastened to sheathed walls, and the common practice is to nail them all around the edges, but, in this case, expansion and contraction soon loosen the sheets either by drawing the nails or by tearing the nail holes. The plan of attachment just described, and illustrated in Fig. 3, is to be recommended even when the sheets are fastened to a flat surface.

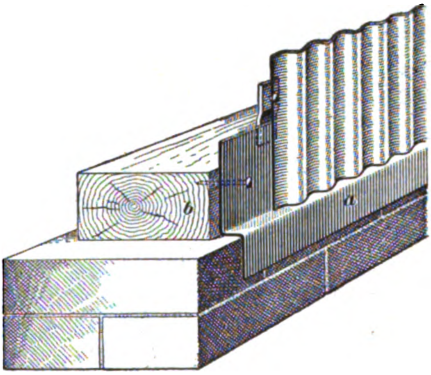


FIG. 4

8. Fig. 4 shows how the corrugated sheets may be put on at the base of the framework. A *base strip a*, made in the form of an offset, is securely nailed to the wooden sill *b*, the strip being flanged so that it may cover the exposed portion of the wall. The sheets are clamped to the top edge of this strip with cleats 1 inch wide by ⅛ inch thick, similar to that shown in Fig. 3.

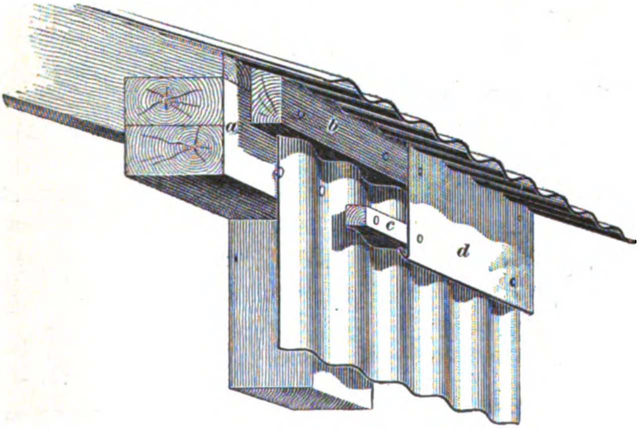


FIG. 5

9. Fig. 5 shows how the sheets are finished at the eaves. The top edges of the sheets are nailed to the plate *a*. A strip of wood *b* about $1\frac{1}{4}$ inches thick, cut on one edge to fit the profile of the corrugations of the roof, is nailed to the upper edge of the plate above the sheets, and another strip *c* of the same material is nailed to the lower edge of the plate. A facia of crimped sheet iron *d* covers both strips and forms a drip at its lower edge, as shown. This arrangement makes a neat, water-tight, and wind-proof connection between the siding and the roof.

10. Fig. 6 shows the finish at the corners of the building; this makes a water-tight junction and presents a neat appearance. Since the corrugated iron is laid against the framework, it is necessary to nail $\frac{7}{8}$-inch wooden strips on the outer faces of the corner post *a*. The corrugated iron butts against the edges of these strips, and a crimped sheet-iron corner piece is sprung over and locked into the corrugated wall sheet, as shown.

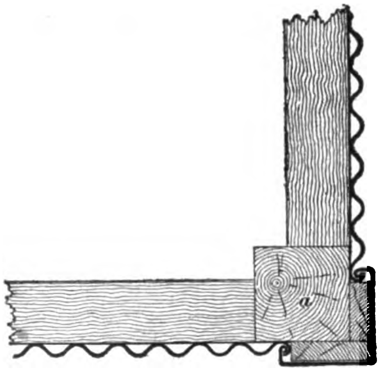


FIG. 6

This arrangement can also be used around any window or door opening. The arrangement shown in Fig. 4 may also be used over the lintels of any door or window opening.

11. Corrugations in common use measure about $2\frac{1}{2}$ inches, from center to center, and are about $\frac{3}{4}$ inch deep.

Black corrugated iron should always be painted with the best quality of metallic paint before it is secured in place.

12. Stamped siding is most commonly employed for covering large flat surfaces of outer walls, the sheets being pressed to such a shape that they resemble *rock-faced*, or *tooled*, stonework or brickwork. This siding is stamped in plates 10 feet long by 2 feet wide, and the plates are sold by the lineal foot. Like crimped sheet metal, it is nailed to furring strips, to ordinary sheathing, or to brick walls, the vertical joints being lapped and closely nailed.

Particular care should be taken to lap all the vertical joints in sheet-metal work, so that the heaviest rain storms will blow with the laps and not against them. It is noticeable in nearly every district that the strongest winds and greatest rain storms nearly always blow from certain directions; these directions should be determined, and the sheet-metal work should be arranged to prevent the rain from blowing into the seams.

Brick walls should always be thoroughly furred to receive the sheet-metal work. It is a mistake to suppose that sheet-metal work can be securely nailed into the joints, because expansion and contraction will very soon loosen the fastenings.

CORNICES

13. Sheet-metal cornices are made in such a variety of patterns, in such a wide range of sizes, and are required to be placed in such a diversity of situations, that there must be a great variation in the methods of construction. Very many designs, however, correspond as far as having moldings continuous throughout their lengths. All are supported by projecting brackets or lookouts. The joints, shape, and material of the cornice proper, and the construction of lookouts, are the particular features in cornice work that will be considered here.

As a rule, cornices are made at the cornice factory, according to drawings and specifications, and are shipped in parts to the building.

Brackets, modillions, dentils, etc. are usually secured to the cornice at the factory. Trusses and check, or stop, blocks are shipped in separate packages. Thus it will be seen that the cornice setter or tinsmith is only required to assemble the several parts and erect them in place on proper supports. The supports in general use are wood or iron, the latter being employed in the better class of buildings.

14. Cornice Erection on Wooden Supports.—In Fig. 7 are shown the parts and joints of a sheet-metal cornice as ordinarily constructed in small sections on a brick wall. The foot-molding *a* is fastened to, and supported by, a board and wooden lookouts, the lower member being allowed to hang down below the reglet, or groove, that runs along the joint of the brickwork at the under side of the lookouts. The top of the foot-molding enters the reglet in the next joint above. The paneled frieze *b*, between the trusses, or brackets, *c*, is made up in one piece, the edges being doubled over and secured into reglets as shown. The modillion course, which generally includes the small moldings above and below the plain surface from which the modillions project, is attached to the brickwork in a similar manner and is secured in place with a long, narrow, metallic wedge. If the cornice is erected while the walls are being built, the upper flange of each piece is usually bent over far enough to be safely bedded in, the lower edge of the sheet above being bent over and pushed into the same joint as the work progresses. The soffit *e* may be bent up out of the same piece

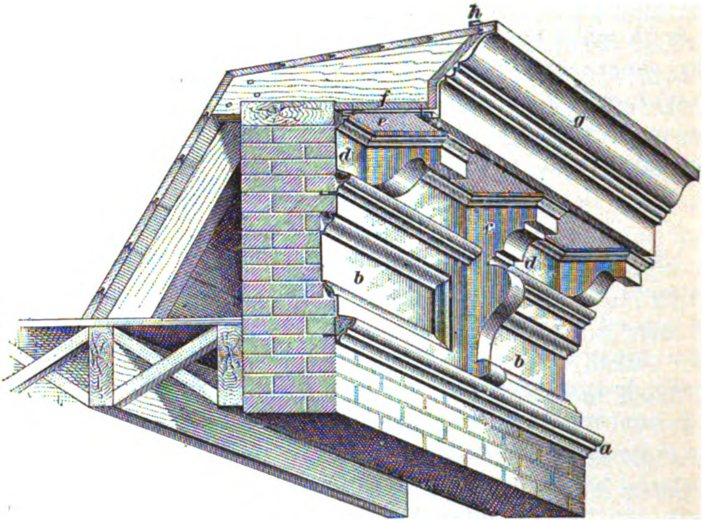


FIG. 7

with the bracket molding. The drawing, however, shows it separate, and secured to the board lining *f*.

The *crown molding g* is bent over the top of the roof boards, leaving an edge turned up, as at *h*, for easy connection to the sheet metal of the roof. The lower edge of the crown molding should be made to form a drip, as shown, and should be securely nailed to the board lining *f*.

The brackets and trusses, which are hollow and built up from stamped sheet metal, are riveted and soldered in position. It is difficult, however, to properly attach them when the cornice is put up in sections, as shown, so it is advisable to have these projections riveted and soldered on before the cornice is erected. In the construction of cornices, particular care must be taken to avoid pockets in which water may accumulate. If it is suspected that a water-tight pocket exists, a small hole should be punched at the lowest point to allow any water to drain out. If this is not attended to, these pockets may fill with water, freeze, and burst.

15. Another plan for fastening cornices to brick walls is to spike boards against the face of the walls, put the cornice on top of the boards, and nail it in place. The former method, however, is preferable, not only because the nails will show by the latter method, but chiefly because the boards are likely to warp and consequently cause the cornice to become distorted and loosened.

The cornice work shown in Fig. 7 is attached to a brick building with a flat roof. The roof pitches down to the back of the building and the conductor pipes, of course, are in the rear. When the roof pitches in the direction of the cornice, a gutter is usually formed at the back of the crown molding.

16. Iron Supports.—It is comparatively easy to fasten a sheet-metal cornice to a wooden building, or even to woodwork that is spiked to brick buildings; but it is considerably more difficult to properly fasten a cornice to brick, stone, terra cotta, or to the structural ironwork of modern fireproof buildings.

Fig. 8 shows a system of bracing well adapted for a cornice at the top of a brick wall. The framework or bracing shown, which is mostly composed of angle irons, should be built into the wall. These frames should be placed from 2 to 4 feet apart, according to the projection of the cornice. The cornice is sometimes bolted to the framework after the wall is finished.

The strongest and best plan, however, is to attach the iron frames to sections of the cornice that are about 14 feet long, hoist these sections, and set them on the wall when it has been leveled to the required height, as at *a*. When lined up and in proper position, the frames are tied temporarily in place to keep the cornice from toppling over until the brickwork *b*, *b* is all filled in and has set. This mass of brickwork must be sufficient to more than counterbalance the weight of the cornice. If there is any danger of the cornice being too heavy for the counterweight, the legs *c* must each be tied separately to some beam or other rigid part of the building.

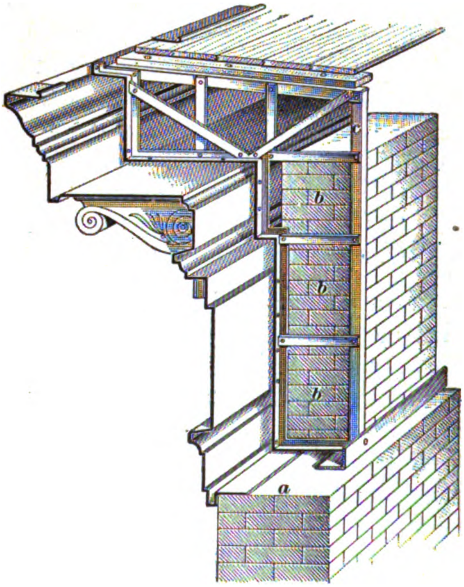


FIG. 8

There are, of course, many kinds of iron supports for cornices other than that shown in Fig. 8, but, with a little judgment, a lookout for any position can be designed. The principal points to be considered in such a design are: (1) to obtain a band of iron that will follow, in a general way, the contour of the cornice; (2) a means of bracing this iron band

and preventing it from changing its shape; (3) a means of rigidly securing the iron band to the building, iron beams, or columns, being preferable for anchoring points.

17. Joints in Cornices.—Different mechanics have different methods of making vertical joints in cornices; some of these are very neat, strong, and durable, while others should not be tolerated. The only two joints worthy of mention here are the *butt joint* and the *lap joint*.

18. A **butt joint** is shown in Fig. 9. The edges of the sheets *a*, *a* that form the cornice are trimmed perfectly square and straight, so that when brought together they will fit closely. A strap *b*, which is made from the same metal as the cornice, is then riveted the entire length of the vertical seam, and its edges are soldered to the back of the cornice, as shown. The rivet heads are all on the outside, and the process of riveting draws in the heads and makes them scarcely visible. The rivets should be as close together as possible.

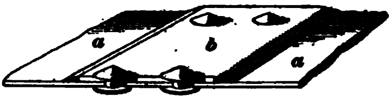


FIG. 9

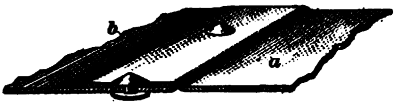


FIG. 10

Fig. 10 shows a **lap joint**. The sheets are lapped over each other a distance of $1\frac{1}{4}$ inches and then riveted closely. The back sheet *a* is dressed forwards to be flush with the other, as shown, and the back edge is then soldered, as at *b*.

19. Both of these joints are strong and durable. The butt joint, however, is neater than the lap joint. A first-class mechanic can make one of these joints so that a perfectly smooth surface will be obtained.

The *rivets* for galvanized-iron cornices should weigh $1\frac{1}{2}$ pounds per thousand, for Nos. 24, 26, 28, and 30 sheet iron. The rivets for copper cornice work should weigh 1 pound per thousand.

20. Cornice seams, or horizontal joints, are also made in a variety of ways, but the following methods illustrate good practice when the joints must be made on the job.

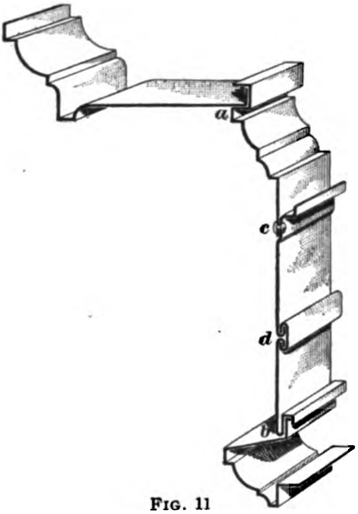


FIG. 11

Cup joints are shown at *a* and *b*, Fig. 11. The position of the copper in these joints shows how they appear when the cornice is being fitted up. After the cornice is lined up in place and the vertical joints are all made, the edges are bent over twice, thereby locking the seams. These joints are necessary only in large cornices.

When a seam must be made on a flat surface, such as on a wide frieze, either of the methods shown at *c* or *d* may be employed. The seam at *c* is lapped and riveted like that shown in Fig. 10; a stiffener, however, is bent at the back to keep the seam straight. This is the stronger seam of the two. It is preferable to that shown at *d* in places where rain will wash over it. When it is desired to form a very close horizontal joint, the *clinch seam* at *d* may be used. The edges of the sheets are bent over and butted together in position. A cap is then slipped over the seam as shown. When the work is all lined up, the seam is closed by flattening down the cap. This process draws the sheets together and makes a very close seam.

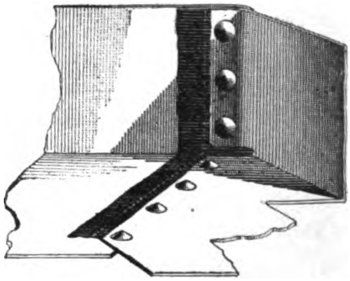


FIG. 12

21. Miters.—All miters in cornice work, pediments, and elsewhere may be classed as *lap miters* or *butt miters*.

Outside miters are made in different ways, but there are only two reliable methods. The first, or lap miter, is made by returning a ½-inch flange on the inside of the miter, as shown in Fig. 12. This flange must be riveted closely and soldered on the inside. The chief objection to this miter is that the edge of the sheet is visible.

To make a close miter, it is necessary to bevel and butt the edges as shown in the butt miter, Fig. 13. In this figure, the edges of the copper are fitted closely together. A copper angle strap *a* is then riveted and soldered securely in the inside angle the full depth of the cornice. A few gussets are then riveted and soldered across the inner corners as shown. These gussets help to keep the cornice square during shipment and prevent the edges from being pulled apart by expansion and contraction. The method shown in Fig. 13 should be used on all first-class work.

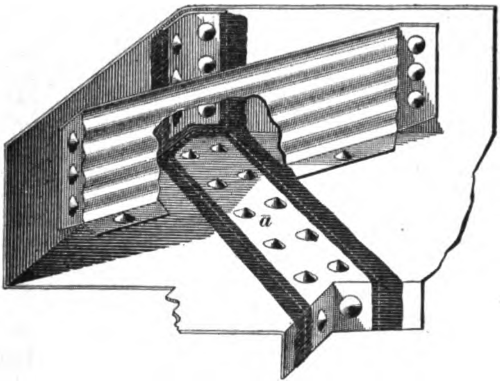


FIG. 13

Inside miters are made and reinforced in a similar manner, but owing to the fact that gussets cannot be used, it is advisable to rivet a reinforcing angle strap over the ½-inch flange.

22. Iron-Beam Cornices.—In some buildings, the ironwork of the first story or "store front" does not project beyond the wall; and the iron beams, such as those over store windows, often require to be covered with a metal panel or cornice, or both combined.

Fig. 14 shows a *panel course* attached to an iron I beam. A series of bar-iron braces *a* are secured to the web of the I beam and the panels are fastened to them with countersunk screws, so that the heads will finish flush with the face of the panel. A rabbet is formed at *b* to cover the joint between the top of the window frame and the iron beam. When the beams are in place, and before the brickwork *c* is built thereon, the sheet-metal panel course is pushed over the face of the beam and doubled over at the back edge of the upper and lower flanges, as shown at *d*. The braces *a* thus merely support the frieze and prevent it from sagging. If desired, a plank instead of iron straps may be bolted to the web of the beam to support the panels.

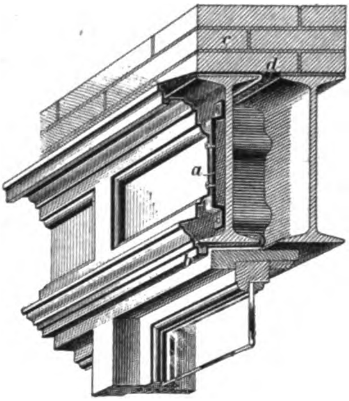


Fig. 14

23. String-Course Cornice.—A string-course cornice, or store cornice as it is often called because it is so commonly used over store fronts, is shown in Fig. 15. The lookouts are made of band iron $\frac{1}{4}$ in. × $1\frac{1}{2}$ in. and are tied into the brickwork at *a* and *b*, these ends being built into the wall. The lower ends of the lookout frames are continued down over the face of the beams and along under their lower flanges, and are then bent up at the back, as shown at *c*. An angle iron running the whole length of the cornice is bolted to the ends as shown at *d* and keeps them in place. A sloping platform of matched boards is screwed on the top of the lookouts. The sheet-metal work is bolted to the band iron in the usual manner, a soldered double seam with cleats is made at *e*, and the top covering enters the wall at *f*. An iron plate, either plain or ornamental, is usually secured at *g* to form the soffit of the beams over the opening.

After the beams are set on their columns, and before the mason begins to build on them, the cornice must be set in position. The cornice being set true and level, the mason finishes the wall up to the course *h*; then the flashing is put on, the top edge *f* being bent over about 3 or 4 inches, as shown. When this is finished, the mason proceeds to build the superstructure. If the wall is built before the cornice lookouts are ready, the anchors *a* and *b* must pass through the wall and be bent over at the back, and the flashing *f* must be let into the reglet and be batted with lead, the reglet being filled with mastic or other cement in the usual manner.

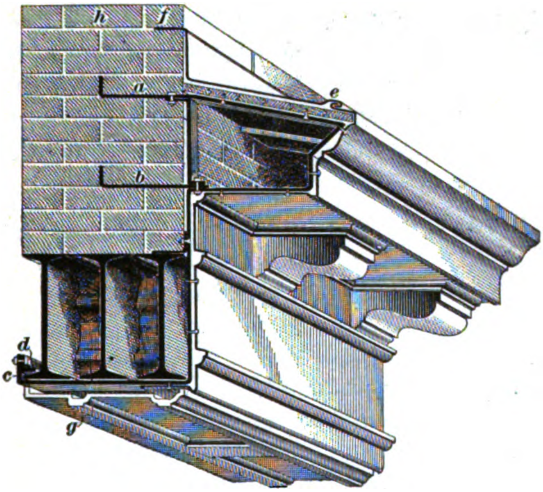


FIG. 15

24. In many cases, it is advisable to make the lookouts of cast iron instead of wrought iron, as, for example, when a very large number of small lookouts having the same shape are required. If the molding is small and extends as a belt, or string-course, around the building, it is certainly advisable to use cast-iron lookouts. The chief advantages of cast-iron lookouts are accuracy in the lines of the cornice, economy in construction, and durability.

Accuracy is insured when the cast-iron lookouts are properly lined up, because each lookout is a duplicate of the others, all of them being cast from the same pattern. Economy of construction lies in the fact that the labor of making the lookouts and of fitting the sheet metal to them is reduced to a minimum; and the durability lies in the fact that cast iron is less corrosive than wrought iron. Iron lookouts should always be coated with asphalt or other protective covering in order to prevent rapid corrosion.

25. Metals Used for Cornices.—Galvanized iron is commonly used for the cornices of ordinary buildings, and should be painted on both sides to protect it from corrosion. Sheet copper (cold-rolled) is preferable, however, in every case. The metal itself costs considerably more than iron, but the labor and other expenses relative to its construction and installation are about the same.

26. Copper cornice work does not require to be painted for protection. It is, in fact, better practice to leave the metal thoroughly scoured, clean, and uncovered, and allow the weather to slowly change its color. Copper sheet-metal work has naturally a dark-green tint, but it often takes a very long time to get that color. The time required depends considerably on the climate, the weather, and the composition of the atmosphere. Where the rain becomes acidified by falling through air charged with sulphurous gases, the color changes rapidly, but where it falls pure and clear, the copper changes color very slowly.

When it is desired to hasten the color, it is customary to produce an *artificial* color by washing the copper with acids. One method is to thoroughly scour all the copper work to remove any grease or acid spots, then wash the entire surface with a solution composed of 1 pound of sal ammoniac to 5 gallons of water. This solution should stand about 24 hours before it is applied. After the copper has been uniformly covered with the solution, it should be allowed to stand for a day or two and should then be lightly sprinkled with clean water. If the water is put on too freely, it will run in streaks. After a few days the copper work should have a beautiful and uniform greenish-brown color that will stand the weather. The same effect may be produced by using vinegar and salt in the proportion of ½ pound of salt to about 2 gallons of vinegar.

27. Soldered Seams.—Although it is advisable in all sheet-copper work to solder the seams on the back where they cannot be seen, it nevertheless often happens that some parts must be soldered on the front. The solder does not change color like the copper, and, consequently, when not properly treated, such seams tend to spoil the appearance of the work.

To give solder a copper color, it is necessary to deposit a copper plating on it. This is accomplished by first thoroughly scouring the seams, and then washing them with a solution of *sulphate of copper* and water. The solution should be strong. When applied with a brush to the solder, a film, or plating, of metallic copper is immediately formed over the solder, and by repeated applications a fairly substantial coating of copper is obtained.

WINDOW SILLS, LINTELS, AND CAPS

28. Window sills are made of sheet metal to represent cut-stone sills. They should be filled in behind with timber of the proper size. The metal sills are usually slipped over the wood backing and are fastened to the wall by nailing closely through the flange *a*, Fig. 16, which extends along the bottom and up the sides. The top flange *b* is made wider than that at *a*; it is nailed against the window frame, and is bedded in white or red lead to make it water-tight. A better plan, however, is to bed the window frame over the metal sill with red or white lead, the metal being flanged and passing up

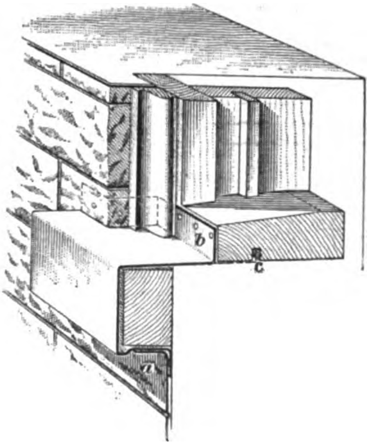


Fig. 16

into the groove *c*. Metal window sills are generally used on galvanized-iron fronts. Copper is seldom used for this work.

29. Window lintels are covered in a similar manner, the chief difference being that the top flange of the lintel is overlapped by the metal siding above it. The soffit of the lintel flanges down against the top of the window frame and is nailed to it. Particular care, however, should be taken to have a well-inclined wash on the lintel. Horizontal surfaces, particularly pocketed surfaces, are very objectionable and should always be avoided.

30. The covering of bay windows, architraves, pediments, etc. depends altogether on the design. An important point to be considered in the line of sheet-metal work for bay windows, pediments, etc., is the provision for lookouts and other projections to which the cornice and other moldings must be attached. Small moldings are usually placed on the flat sheathed surfaces, while lookouts are required for cornices and other large projections. It is advisable, in all the work, to provide solid backing for the sheet metal. When wooden lookouts are used, they should be so made that the metal work can be nailed across the grain of the wood, not with it. The expansion and contraction of the metal soon draws out and loosens all nails driven in the direction of the grain.

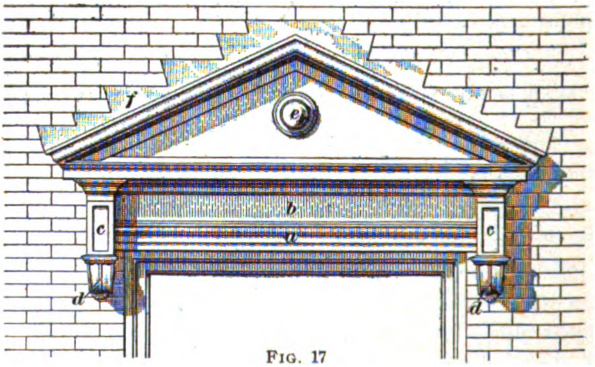


FIG. 17

31. Window caps, like all other ornamental parts of sheet-metal work, are made up from stock sizes and shapes of bent or stamped sheet metal. Fig. 17 shows a sheet-metal window composed of an architrave *a*, a frieze *b*, and two impost blocks *c*, *c* supported by brackets, or trusses, *d*, *d*. The impost blocks support the pediment *e*, and a counter-flashing at *f* against the brick wall makes the top water-tight. If the cap is put on after the walls are built, it is customary to fasten it in place against wooden lookouts, as shown at *b*, Fig. 18. Furring strips *a*, *a* are nailed to soft-pine plugs, previously driven into the wall, and the lookouts *b* are set about 1 foot apart along the line of the furring strips and nailed to them. Two special lookouts are to support the trusses. The sheet-metal cap is then set over these lookouts and is rigidly nailed to them. The metal is extended under the soffit of the lintels and flanged down against the hanging tile of the window frame, and is neatly finished with an angle molding bedded in white lead and well nailed in place. The wash *c* of the cornice is turned up against the wall and is counterflashed in the usual manner.

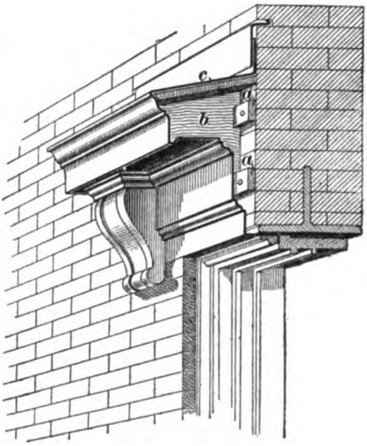
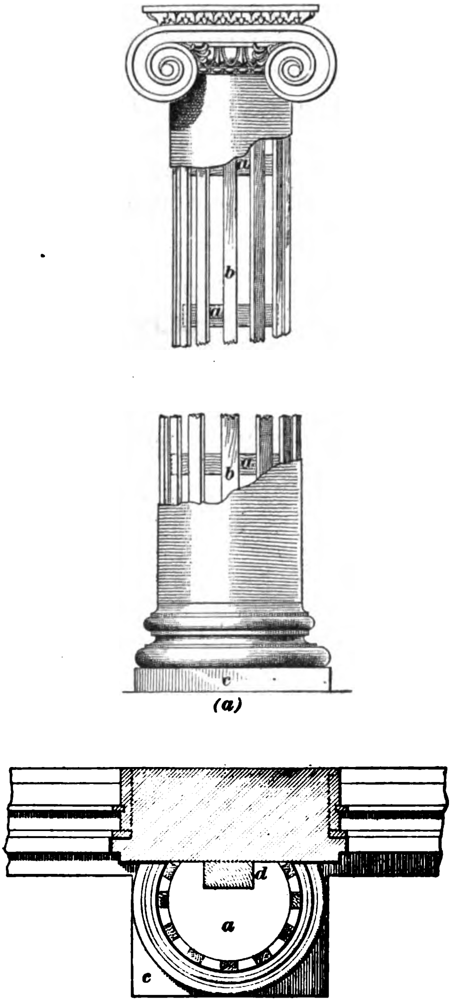


FIG. 18

If the wall has not been built, it is advisable to use iron lookouts and build them in the brickwork when the wall has been brought up to the proper height. The upper surface of all window caps, sills, and cornices should be carefully protected during the erection of the building. Every window cap, and indeed every other projecting molding or cornice, should be closed water-tight on top with a sloping deck, or wash, and should be sufficiently strong to sustain the weight of a man.

COLUMNS

32. There are many kinds of columns and pilasters, and different methods of constructing them. In a general way, however, Fig. 19 illustrates common practice. This figure shows in elevation at (*a*), and in section at (*b*), a three-quarter column, such as is used for the front of a building. The column is braced by wooden blocking, which is composed of 1½- or 2-inch horizontal blocks *a*, *a* that are spiked to an upright post *d* and spaced at intervals of not more than 2 feet. Vertical strips *b*, *b* are nailed to the face of the blocks, and are run from the square plinth *c* to the top of the capital. The sheet metal that forms the column is continued down to the plinth, and up to the block or other member over the capital, the seam on *c* being soldered water-tight. The back edges of the sheet are nailed to the face of the wall in the regular manner. The base is then put in place and



(a)

(b)

Fig. 19

soldered to the column, after which the capital should be soldered to the column. This is one of the best methods of bracing sheet-metal columns.

The same method is employed in fireproof construction, except that iron is used instead of wood. Pilasters are formed and covered in the same manner as columns. In all column and pilaster construction, the formation of pockets wherein water may accumulate should be avoided.

FIRE-DOORS AND FIRE-SHUTTERS

33. Wooden fire-doors may be covered with any kind of sheet metal that has a high temperature of fusion. Copper and zinc are not suitable for this work; galvanized iron and tin are therefore used, though tin seems to have the preference. The covering is generally put on as follows: The outer edges of the door are covered first with a strip of tin, which is returned over both faces to a distance of about 6 inches, the edges being nailed to the woodwork and turned over, as shown in Fig. 20. The flat part of the door is then covered with sheets 14 in. × 20 in., in a manner similar to that employed on flat roofing. This arrangement avoids seams around the edges of the door, and allows it to shut with a close contact. A heavy body metal should be employed for this work, because the efficiency of the covering in case of fire depends on the thickness of the metal, and not on the thickness or quality of the protecting coat. The seams should all be closely nailed, and then locked and

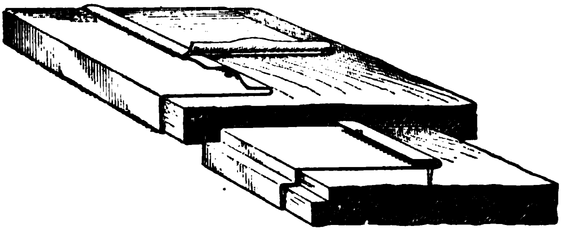


FIG. 20

thoroughly pounded down. A layer of asbestos cloth should be placed between the tin and the wood.

Corrugated-iron doors and **shutters** are also extensively used, but they do not form as efficient fire-stops as ordinary wooden doors or shutters that are properly covered with tin and asbestos. The corrugated iron must be thoroughly braced with an angle-iron or T-iron frame.

The greatest objection to iron fire-doors and fire-shutters is that they warp very easily when attacked by flames. Plain iron warps so much that it is practically useless as a fire-stop. Fig. 21 furnishes a good illustration of this. The door shown is composed of one sheet of thick metal, and is provided with iron cross-pieces to which the hinges are riveted. The fire plays against the inside of the door and warps the sheet outwards, thus allowing an opening for the flames, as shown.

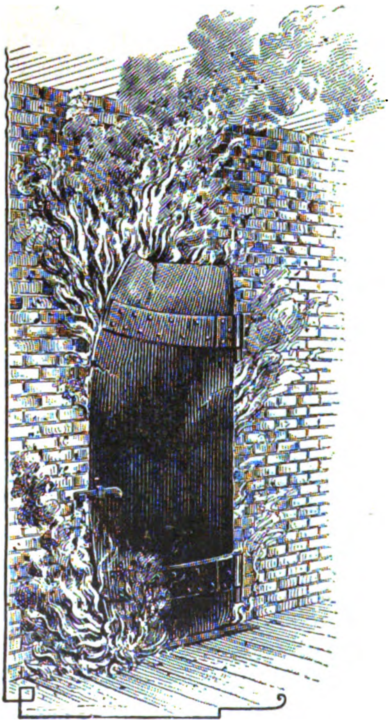


FIG. 21

COPINGS

34. Wall Copings.—The tops of all brick walls must be made waterproof, otherwise rain will soak into the wall heads and ultimately ruin them. When cheap, light coping stones are used, it is necessary to lay a sheet of metal (preferably lead or copper) under them, as shown in Fig. 22. The sheet metal is simply laid on the brickwork and bent over about 1 or 2 inches at each edge. The stones are then bedded in place in the usual manner.

35. Coping Blocks.—When coping blocks are used to surmount cornices, the flashing or wash of the crown may be extended through to the back of the wall, where it may connect to the roof covering, or to a gutter lining, as the case may be. When it is necessary, however, to entirely cover the blocking course with the same kind of metal as the cornice, the metal work of the cornice may be extended up and continued over the blocking course, as shown in Fig. 23, the sheets being crimped and held in place by cleats in the seams *a*, *b*, and *c*. A wooden wall cap is placed on top of the brickwork to protect the top course and to take the cleat nails.

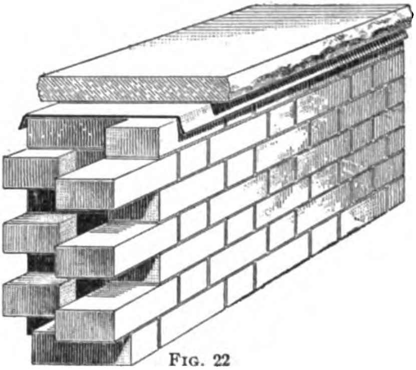


FIG. 22

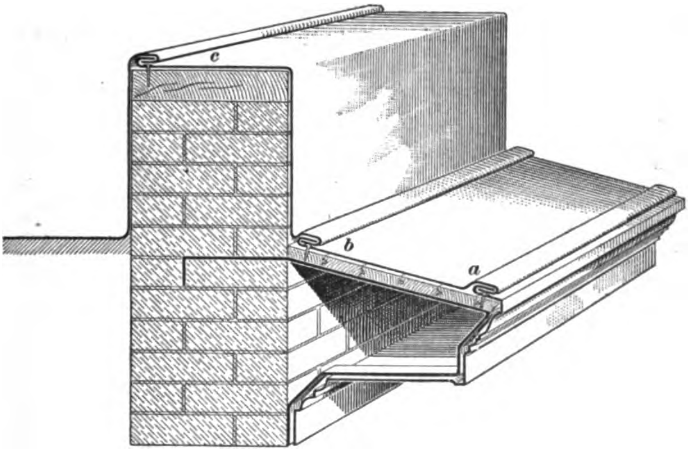


FIG. 23

36. Stone cornices may be flashed as shown in Fig. 24. The copper is bent over the face of the stone and doubled over with a beaded edge on the under side to form a drip.

This also prevents the flashing from rising in front. When the top surface is narrow—that is, less than 12 inches—it does not need to be fastened, but when it is wide, the copper should be held down with fastenings, as shown at *a* and *b*.

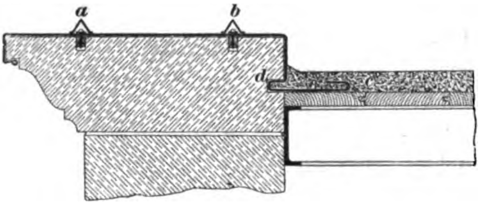


Fig. 24

The arrangement shown in Fig. 24 is used at the junction of a stone cornice and an asphalt roof laid on fireproof construction, the asphalt covering being shown at *c*. Sometimes the copper is bent down flat over the back of the stone, but the best method of attaching it is to groove the stone at the back and let the copper into it, as shown at *d*. This holds down the flashing at the back.

37. The common method of fastening the sheet to the stone is to drill $\frac{1}{2}$- or $\frac{5}{8}$-inch holes at intervals over the surface of the stone and fill these holes with lead. The holes should be cut wider at the bottom than at the top, so that the lead plugs cannot be pulled out. After the holes are drilled, an iron rod, whose diameter is less than that of the screws to be used, is greased and placed upright in each hole. Molten lead is then poured around the rod until the hole is full. The rod is then pulled out, and when the flashing is all laid and neatly set in place, it is screwed down to the lead plugs with brass screws.

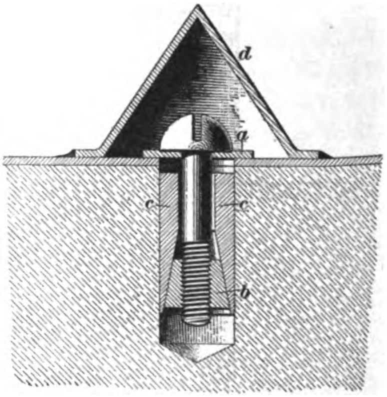


Fig. 25

Expansion bolts, shown in Fig. 25, are now generally used for fasteners. After the holes are drilled and the stone covered, the holes are "found" and the expansion bolts are inserted. A washer *a* is placed between the bolt head and the copper, and the bolt is screwed down tight. This draws up the tapered, or wedge-shaped, nut *b* and presses the sides *c*, *c* against the sides of the hole. A cone *d* is then soldered over the fastener, as shown, to make it water-tight. If the fasteners are not used, the copper is likely to rattle when the wind blows.

38. Chimney caps are made in different styles. The most simple, and perhaps most common, form is a plain sheet-metal cap that is slipped down over the brickwork about 6 inches, the sides of the cap being nailed into the joints of the brickwork. A superior chimney cap, however, is shown at *a*, Fig. 26. The brick chimney is built up to the course *b*, then the cap is bedded on, and finally the brickwork *c* is filled in from the top, so that its weight on the flange, which is turned over the course *b*, will prevent the cap from being blown off. The moldings of the cap, being of small projection, do not require any lookouts. The brickwork must, however, be built up tight to the top of the cap to prevent it from settling down and flattening the molding.

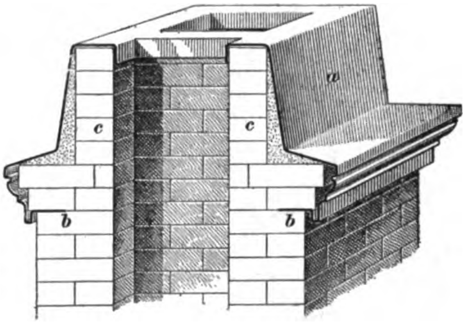


Fig. 26

BALUSTRADES

39. Balustrades, like cornices, etc., are constructed either with wooden or with fireproof supports, the kind to be employed depending on the construction of the building. Balustrades, pedestals, etc. on non-fireproof buildings are usually backed with, or secured to, woodwork, while those on fireproof buildings are nearly always supported by ironwork or brickwork.

Fig. 27 is a section through a balustrade that is commonly employed where the cornice deck pitches to the front and the roof pitches to the rear. The base rail *a* extends down to the deck, the metal being flanged over and soldered to the roofing.

When the deck over the cornice grades back toward the balustrade, and when the base rail extends down to the deck, it is necessary to solder in drain tubes to take away the water. This will prevent a pool of water from forming against the base of the balustrade. The trouble, however, with such tubes is that they are liable to become clogged with snow, etc. The best arrangement is to elevate the base rail 2 or 3 inches above the deck. Roof-cornice decks, in fact, should always pitch back to the roof to prevent rain from dripping over the cornice. When the base rail does not extend down to the deck, it is usually composed of solid timber and is entirely covered with sheet metal.

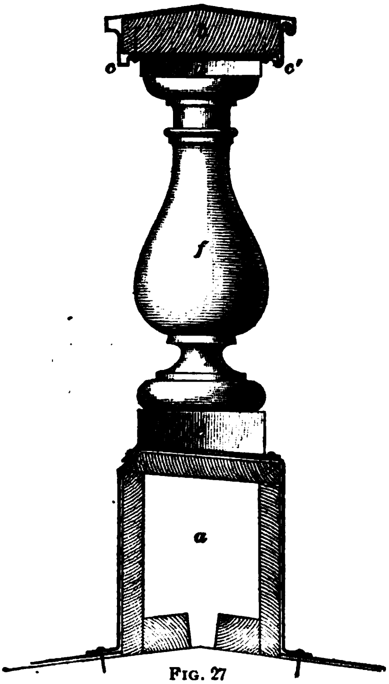


FIG. 27

To prevent the rail from sagging, wooden blocks covered with sheet metal are frequently inserted under the rail at distances varying from 6 to 8 feet apart. The coverings of these blocks are bent over at the top and nailed to the under side of the base rail, while at the bottom they are bent out and soldered as a flange to the deck.

The cap rail *b*, Fig. 27, is usually made of wood and is covered with two pieces of sheet metal with drips formed at *c*, *c′*, as shown. The seams are made at the rear.

40. The balusters *f*, Fig. 27, are spun, pressed, or cast. If they are spun or cast, there will be no vertical joints in their length. If they are pressed, they are put together in halves, which necessitates two vertical soldered seams. Pressed metal is generally used on ordinary work because it is much cheaper than spun or cast metal. The top member *d* and the bottom member *e* of the baluster are usually square. All the members are securely riveted and soldered together before the baluster is set in position. After the cap and base rails are in place and lined up properly, the balusters, which are hollow and flanged at top and bottom, are pushed into place. The flanges are securely nailed to the under side of *b* and to the top of *a*, as shown, the bottom flange of each baluster being soldered water-tight over the nail heads. The top flanges are not soldered, because the drips protect them.

It is generally understood that sheet-metal balusters are strong enough to support the top rail under ordinary conditions; but in cases where a load is likely to be placed on the cap rail, it is advisable to put a strut inside of each baluster, which will take the load off the metal and prevent the baluster from collapsing.

In fireproof construction, the general arrangement is the same, the principal difference being that iron backing is used instead of wood, and that the metal is bolted to the ironwork in a manner similar to that prescribed for cornices.

41. A **pedestal,** as ordinarily constructed, is composed of a framework made of 3″ × 4″ timber, which is spiked to the roof and sheathed, as shown in Fig. 28. The projections necessary for the moldings, etc. are blocked out. In the figure, the pedestal is provided with a panel face and a flat back. The sides may be paneled or plain. The dotted lines show the relative position of the balusters *a* and the cap and base rails with respect to the pedestals.

The sheet metal for the front and sides is made to fit the pedestal and is then put on in one piece. The back piece is then put in place and double-seamed to the sides, flanges *b*,*b*′ being formed at the base and soldered to the deck. The top is then put on and double-seamed over a flange, as shown at *c*, *c*; the double seam is shown turned down and finished at *c*, while it is only half finished at *c'*. The molding, or projection at *d*, is returned on the pedestal and miters with the top rail. The base block, in a like manner, returns and miters with the base rail of the balustrade. If a finial or vase is to be set on the pedestal, the connection should be made with a flange at *e* and should be lock-seamed and soldered water-tight.

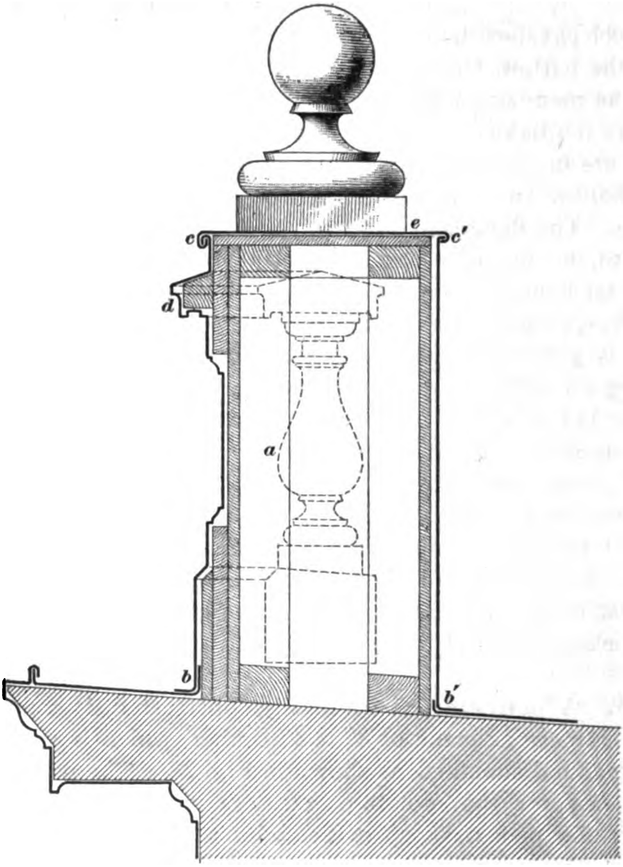


FIG. 28

Corner pedestals are paneled on two sides; this necessitates a vertical seam on the outside and inside corners of the pedestal.

In fireproof construction, the backing for the pedestals is usually composed of brickwork when they are located immediately over the wall head. The sheet-metal covering is then made up in one piece and is slipped down over the brickwork, being fastened to the deck with a flanged seam, as shown in Fig. 28. The top sheet, also, is fastened in a manner similar to that shown in Fig. 28.

When a tall finial that requires a support has to be set, it is advisable to run a rod or iron pipe up through the center of the pedestal and screw the top member of the finial to this support.

When a solid brick backing cannot be obtained, it is necessary to construct a framework of wrought iron, which is thoroughly braced diagonally and bolted to the roof. The metal covering is then placed around the frame, and bolted or riveted in position in the usual manner.

GUTTERS

42. The varieties of gutters that will be treated of in this Section are: *eaves gutters*, *roof gutters*, *parapet gutters*, and *belt-course gutters* of various materials and for various classes of buildings.

An eaves gutter of the simplest kind is shown in Fig. 29; it is known as a **half-round hanging**, or **trough, gutter**, and is commonly used on ordinary frame buildings. The standard widths are 3, 4, and 5 inches measured across the top of the inside. The bead is about ½ inch in

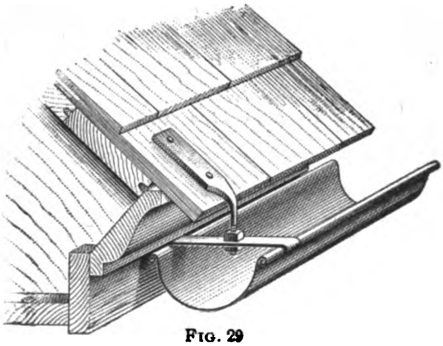


FIG. 29

diameter and is turned outwards. These gutters are suspended from the eaves with adjustable malleable-iron hangers set at about 3 feet centers. When they are attached to shingle roofs, the hangers may be simply nailed or screwed to the shingles as shown in Fig. 29. A neater method, however, is shown in Fig. 30, where the hangers are firmly nailed to the roof-boarding before the shingles or slates are laid. The pitch or grade of hanging gutters should not be less than 1 inch in 10 feet and the gutters should be hung low enough to allow the snow to slide over them.

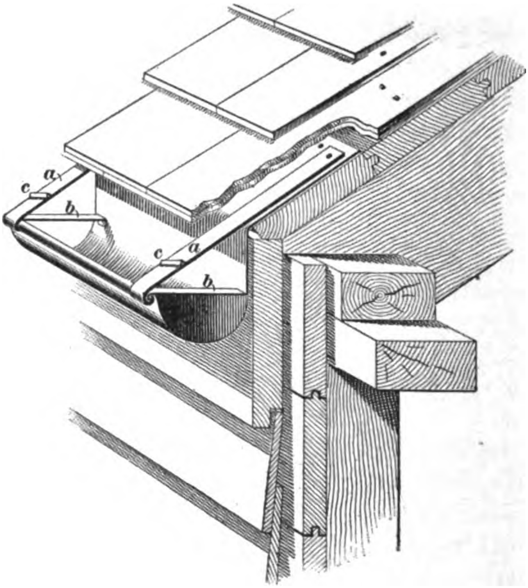


FIG. 30

Three-inch gutters are useful only for porches, bay windows, and other small roofs. The 4-inch size should be used on the main roof when the horizontal or projected area does not exceed 500 square feet. The 5-inch size is used chiefly on factories, warehouses, and at the rear of large city buildings, where the projected area does not exceed 1,500 square feet. Hanging gutters of this class should be used only when the eaves overhang the wall.

When a hanging gutter is attached close to the wall, the back of the gutter is extended up under the shingles or slates at least 6 inches, as shown in Fig. 30, the object being to prevent heavy winds from blowing rain drops against the siding. The gutter is held up in front by tension straps *a*, *a*. The lower ends of the straps are soldered to the bead, and the upper ends are nailed to the roof. Braces *b*, *b* are soldered inside, and above the water-line, to prevent the gutter from sagging or collapsing. Small clips *c*, *c* are soldered on the straps at an angle, to divert any current of water that may flow along the strap and thus escape over the edge of the gutter. This gutter should be graded about the same as that shown in Fig. 29.

43. Molded Eaves Gutters.—Molded, that is, ornamental, eaves gutters are often attached to buildings in a manner very similar to that shown in Fig. 30, but while the gutter in this figure is laid with a pitch, such molded gutters are laid perfectly horizontal. In this respect they are defective, because all gutters should pitch down to the outlet pipes. In good practice, it is advisable not to run a gutter with a horizontal bottom, not only because the gutter is liable to overflow during heavy rain storms, but because a pool of water will remain in the bed of the gutter after the rain has ceased. To prevent an overflow, it is necessary to make molded eaves gutters quite large; and to properly drain them, it is necessary in some cases to install a false bottom that will grade down to the point of outlet with a suitable pitch.

When the gutters are made of iron, they should always be graded in order to prevent deposits of mud, which hasten corrosion.

44. Fig. 31 shows a **copper molded eaves gutter** set on the top of a brick wall of a fireproof building, which is provided with a terra-cotta roof covered with slates. The bed of the gutter rests on a board *a*, which is inclined so as to give the proper pitch. The face of the gutter forms a continuous horizontal molding and is made from cold-rolled sheet copper. The front edge of the gutter lining is bent down over the face and is lock-seamed to the copper molding as shown.

The back of the gutter is extended up over the terra-cotta slabs *d* and under the slates *e*. A series of brass straps *c* are spaced off along the gutter and secured at distances of not more than 3 feet, being bolted to the plank *b* in front with brass lagscrews. The rear end of each strap is run up under the slates and bolted through the terra-cotta slabs with brass bolts of proper length, large brass washers or plates being used under the slabs to prevent the nuts from sinking into them. Each strap is twisted one-half of a turn, as shown, to prevent roof water from working over the face of the gutter. The sheet copper is doubled and pinched at *i* to form a drip. In cold climates, it is advisable to slope the back of the gutter, the space behind being thoroughly filled in solid. This will prevent the gutter from bursting with the formation of ice, if the conductor pipe should choke and the gutter fill with water.

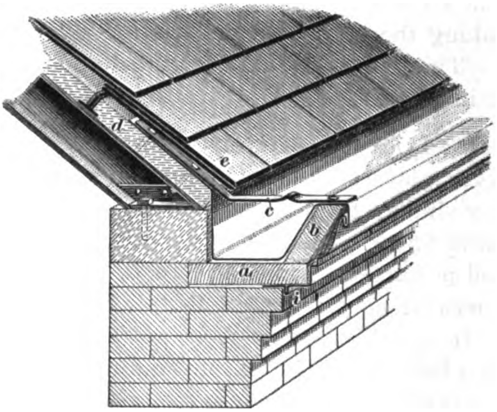


FIG. 31

45. Roof Gutters.—Fig. 32 shows a simple form of roof gutter. It consists of a board nailed to the roof and braced by brackets *a*, *a*. The board is laid on an incline to form the proper grade, and the lining, which is usually bright tin or terne plate, is continued up under the shingles, and nailed down. The front edge is doubled over a strip of metal that has previously been closely nailed to the woodwork. An edge fastened in this manner is called a *blind-nailed edge.*

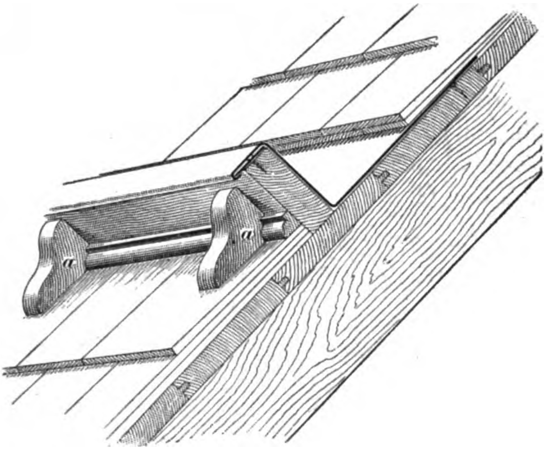


FIG. 32

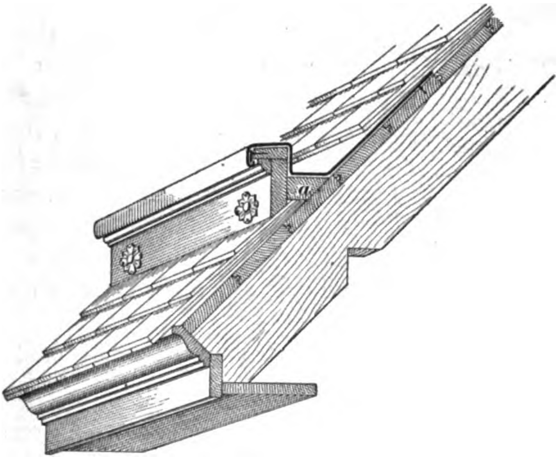


FIG. 33

The necessary incline of this gutter spoils its appearance; to form a roof gutter that will appear parallel with the roof, it is necessary to build it in a manner similar to that shown in Fig. 33. A tapering gutter strip *a*, usually 2 inches thick, is laid to run the whole length of the gutter, and grades the bottom in a proper manner. These gutters really form snow boards, and during winter often become so clogged with snow that the water from melting snow cannot run off the roof freely, but is forced to pass through between the shingles or slates and thus cause a temporary leakage. For this reason, roof gutters are not to be recommended for roofs with a low pitch.

46. Cornice Gutters.—The cornice of a building is very often constructed so it will serve as a gutter also. A **wooden cornice gutter,** sometimes called a *box gutter*, as shown in Fig. 34, is employed in the construction of the better class of framed buildings. The carpenter completes the cornice and forms the bottom of the gutter with the proper grade. The tinsmith then lines the gutter before the shingles or slates are laid. The lining, like those in Figs. 32 and 33, is nailed to the roof and over the front edge of the gutter with a blind edge, as shown.

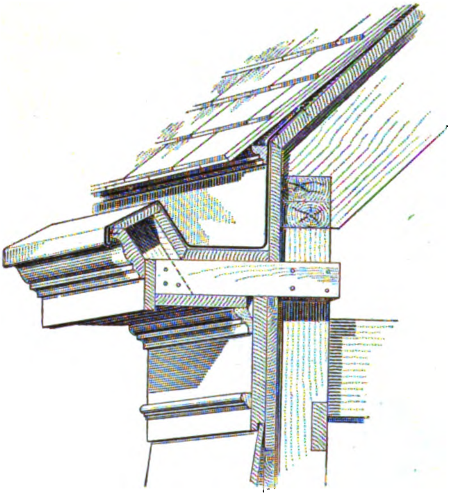


FIG. 34

Sheet-metal cornice gutters are constructed on the same general principle.

47. Terra-Cotta Cornice Gutters.—A terra-cotta cornice gutter for a fireproof building is shown in Fig. 35. The terra-cotta slab *a* of the cornice is backed by brickwork *b*, on which rest the I beams *c* of the roof trusses. The usual angle- or T-iron purlins support the porous terra-cotta slabs. The mason fills in the gutter bed *e* with cement concrete and grades it to the proper pitch. The sheet metal, which is generally 16- or 18-ounce soft- or hot-rolled copper, is then bent up and laid into the gutter, the front edge being bent down into a groove *f*, which is molded in the terra cotta, and the back edge is run up the roof and is overlapped by the slates or tiles in the usual manner. The connection between the copper and the terra cotta is made water-tight by filling the groove full of molten lead, which, when cold, is solidly calked with a hammer and calking tool. If this method of attachment is not desired, the cornice may be molded with a dovetailed projection, so that the metal may be sprung over it as shown in Fig. 36. This will hold down the copper, but it is not so solid as the chalked joint shown in Fig. 35.

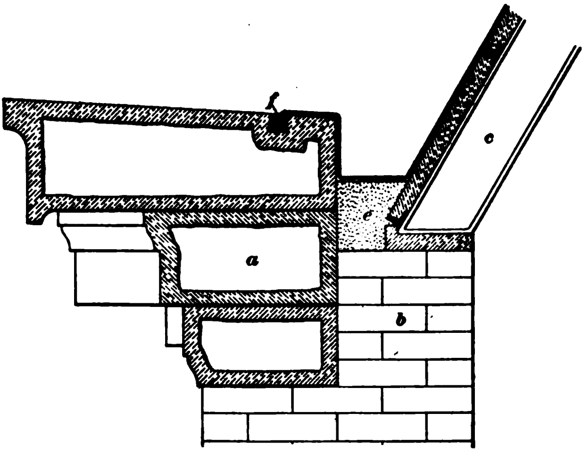


FIG. 35

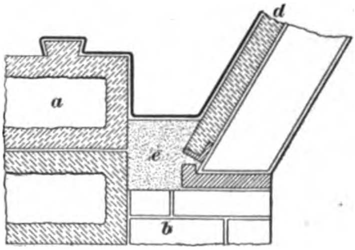


FIG. 36

48. Parapet Gutters.—A parapet gutter for a building of modern fireproof construction is shown in Fig. 37. The only notable difference between this and the box gutters already described is the fact that the gutter is located behind a wall that is higher than the point to which the gutter is extended under the slates. It will be readily seen that there is great danger of the building being flooded if the leader opening should become covered with leaves or dirt, so that rain water cannot escape down the conductor pipe *a* as fast as it flows into the gutter. To avoid this difficulty, an *overflow tube b*, having a sectional area at least equal to, but preferably greater than, that of the conductor pipe, should extend through the wall as shown.

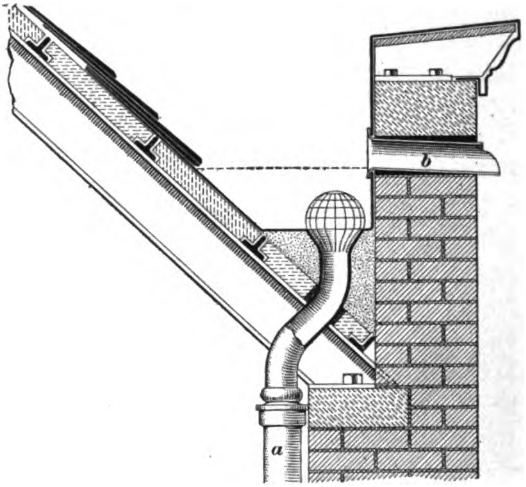


FIG. 37

The bottom of the overflow opening should not be less than 5 inches above the lowest point of the gutter bed, but not high enough to cause the water to overflow any upstands or flashings that the gutter may be provided with. In the figure, the sheet copper composing the gutter and the rear covering of the parapet wall is all in one piece; consequently, the main consideration in locating the overflow tube here is to prevent the water from backing up under the slates and leaking over the top edge of the flashing. The sill of this gutter, like that shown in Fig. 35, is filled in with cement and graded down to the conductor opening.

When the parapet wall is extended higher than about 18 inches or 2 feet above the gutter, it is customary to flash the back into the wall, as shown at *a*, Fig. 38. A joint in the brickwork is raked out to a distance of about 1½ inches, and the copper is bent over and let in as shown. Soft cast-lead bats *b*, *b* are then driven solidly into the reglet, about 6 or 8 inches apart, after which the reglet is filled with elastic cement. The objection to this arrangement, however, is that the expansion and contraction of the gutter is liable to loosen the bats, and the reglet joint may leak.

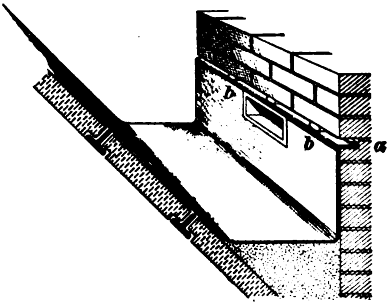


Fig. 38

49. A better arrangement is shown in Fig. 39, in which the gutter is not nailed down or secured at any point except at the conductor opening. The upstand *a* back of the parapet is held down by a number of *cleats* *b*, of which the tops are doubled over the top of the upstand and the lower ends are bedded in the cement sill. A counterflashing *c* of lead or copper is batted into the reglet and overlaps the upstand at least 3 inches. The top of the overflow tube *d* should be on a line with the top of the upstand or a little below it. To avoid nailing down the gutter at the back,

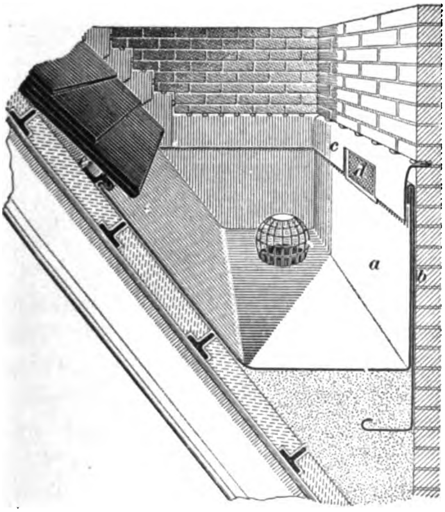


Fig. 39

also to prevent it from rising or shifting, an iron or brass *tilting fillet e* is bolted to the fireproof roofing. The sheet copper is bent under and doubled over this fillet, as shown. The tilting fillet is also advantageous to the slater, because it enables him to start the bottom course of slates with the proper cant.

50. Wooden Tilting Fillets.—Wooden tilting fillets are used when the roof is covered with boards. The fillet is shaped as shown at *a*, Fig. 40, and extends the full length of the gutter. A number of strong cleats *b* are nailed to the roof and bent over the fillet. The gutter is then laid and the cleats are doubled back over the edge, as shown. This is considered first-class practice. The method of laying slates or shingles flat on sheet-metal gutters, valleys, flanks, or other flashings should never be followed. Water will work up between them by capillary attraction.

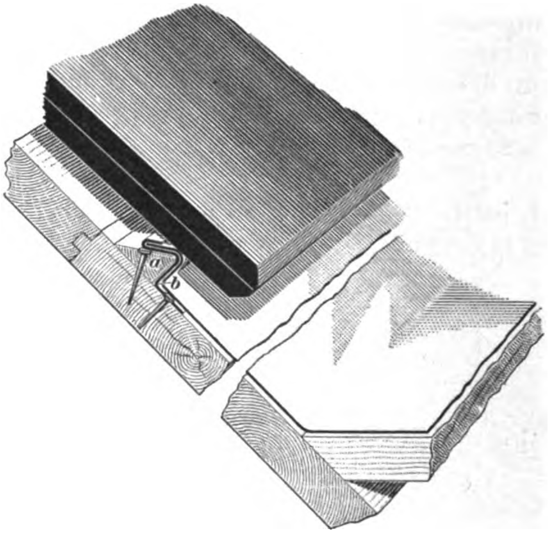


FIG. 40

51. Corbel-Table Gutter.—A corbel-table gutter is shown in Fig. 41. It is supposed to form a belt all around the building, being located about 4 or 5 feet below the eaves.

Such gutters, being so far below the eaves, do not carry much water at any time; they simply serve to carry off the drip. The greater part of the water shed by the roof during heavy showers, shoots over the gutter, this action being most pronounced when the roof covering is of a corrugated character.

A corbel table *a*, which rests on corbels *b*, *b*, forms a support for the gutter. The lookouts *c* are made of cast iron and are set at about 2 feet centers all along the table, their

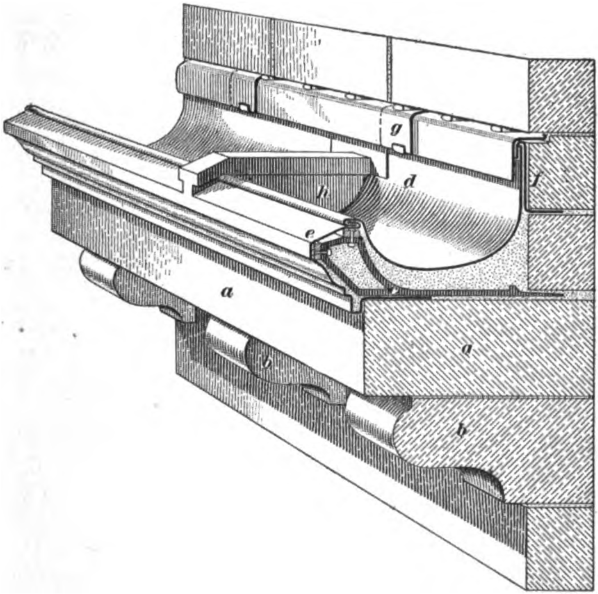


FIG. 41

prongs being let into the mortar joint at the back about 2 inches. The crown molding and its wash are made of copper, the lower edge being lapped about 4 inches over the top of *a*. The top edge is fastened with cleats to an iron bar. Another iron strap, or bar, at *e* runs the full length of the gutter, and the copper is fastened to it with brass bolts. When the molding is in position and properly lined up, the mason fills in the gutter with cement to form a curved bottom with the proper grade. Strong cold-rolled copper cleats *f* are secured to the wall to hold down the back of the gutter *d*; the front edge is double-seamed and soldered as shown. The back is counterflashed in the ordinary manner. If the counterflashing is of lead, the top joints *g* should be locked into one another at the lower edge, as shown, to prevent the wind from raising the corners.

52. When such gutters are long, some provision should be made for expansion and contraction, otherwise they will soon tear apart and leak. In Fig. 41, this is accomplished by introducing a *saddleback joint* at *h*, a cross-section of which is shown in Fig. 42. A plank *i*, Fig. 42, 2 inches thick, that has been previously soaked in oil or asphalt, is set on edge and bedded in the concrete. If the gutters are laid during hot weather the upstands *j*, *j* should be fitted to almost touch the plank, so that during winter, when the gutter becomes intensely cold and contracts, the upstands will be drawn away from the board and take the position shown by the dotted lines. This forms an expansion joint of the best type. The cap, being short, is nailed to the wood and the nail heads are covered with a copper disk, which is soldered water-tight around the edge.

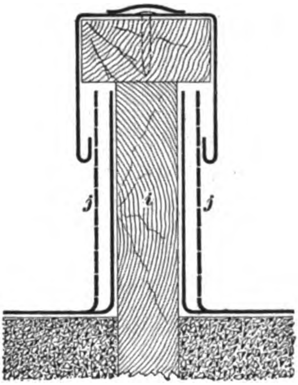


Fig. 42

CONDUCTORS

53. **Conductors,** or **leaders,** as they are often called, are the pipes that conduct or lead away water from the gutters. They may be classed as *inside* or *outside leaders*. Inside leaders are not treated in this Section.

54. **Outside Leaders.**—Outside leaders are fitted up against the outside of a building. They are made in many shapes and of different metals. Fig. 43 shows the **round-pipe leader** as usually erected. These leaders are most always made of tin by the tinsmith, who also makes the elbows *a*, *a*, *a*, which, usually, are altogether too sharp. Tin straps *b*, *b* are soldered to the leader at intervals of about 6 or 8 feet and are nailed to the walls, as shown. Round leaders are not suitable for outside service in cold climates because they persistently freeze and burst.

Fig. 43 illustrates an ever-recurring spectacle in cold weather, when snow lies on the roof and the temperature of the air is below the freezing point. The sun shines on the roof, but not on the leader; thus, the snow on the roof melts and the water trickles down the leader, and, by the time it nearly reaches the bottom it becomes frozen to the sides of the leader. This ice slowly thickens until the leader is entirely choked at that point which, in Fig. 43, is the lowest elbow.

The remainder of the melted snow then gathers in the leader and fills it. This water now solidifies and bursts the leader as shown. The pipe has burst because it could not stretch enough to accommodate the increase in volume of the water as it was changed into ice.

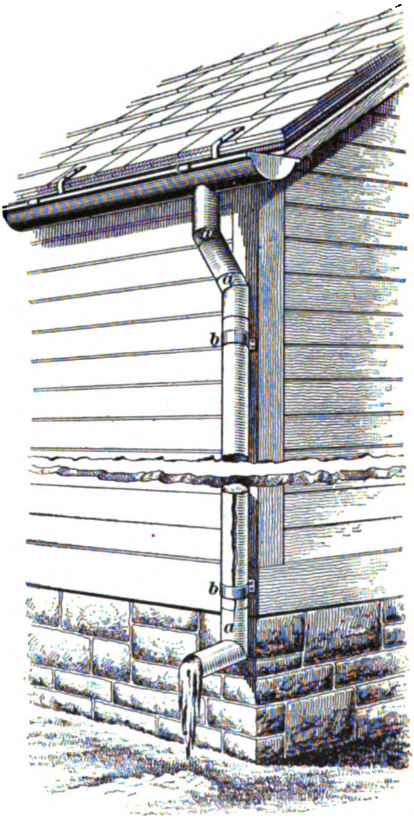


Fig. 43

55. Expanding Pipes.—Expanding pipes should be used to overcome the trouble from frost. A common form, shown in Fig. 44, is simply a corrugated round pipe. The corrugations allow the pipe to increase enough in diameter to compensate for the formation of ice inside, without bursting the pipe. If the pipe is frozen repeatedly, it will ultimately burst, because it takes a permanent set every time it is thus expanded. These pipes are usually made of galvanized iron or cold-rolled copper, in 8- or 10-foot lengths.

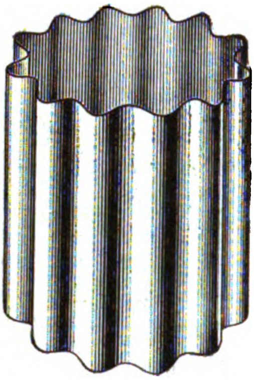


FIG. 44

56. Square or Rectangular Leaders.—These leaders are made of crimped or corrugated sheet metal, and are often used to obtain a more ornamental effect than is produced by round leaders. They should be supported by ornamental bands in a manner very similar to the plain straps shown in Fig. 43, the straps being made so that the leaders will hug the wall. If the walls are built of masonry or brickwork, it will be necessary to drill holes at the back of the bands, and then drive soft-pine plugs into these holes, cutting them flush with the face of the wall for the purpose of receiving the spikes; for good work, expansion bolts should be used.

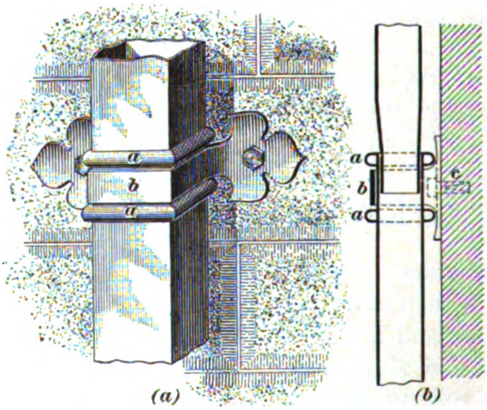


FIG. 45

In climates where there is no danger of outside leaders being frozen, the best method of attaching rectangular leaders in a neat and strong manner to brick, stone, or terra-cotta walls is shown in elevation in Fig. 45 (*a*) and in section in Fig. 45 (*b*). Two copper beads *a*, *a* are soldered around the top edge of each leader and a cast-copper band *b*, provided with ornamental lugs, clasps the top of the leader against the building. The lugs are fastened to the walls with expansion bolts, as shown by dotted lines at *c*. The leaders are connected together by slip joints, as shown in the section. Each band thus supports a section of the leader, which should not exceed 8 feet in length. This arrangement allows each section to expand and contract freely; if all the joints are soldered together, the leader forms into one long rigid line, which soon becomes loosened by expansion and contraction. These leaders should be made with the crimps running across them, not lengthwise, so as to secure a very neat, flat, and stiff surface.

Beaded tops and cast bands are not adapted for outside leaders in cold climates, because the beads and the bands are not pliable enough to resist the action of frost. The best attachment for such climates is composed of either a brass or a copper eye, which is riveted and soldered securely to the back of the top end of each section of the leader. These eyes are bolted to bronze hooks that are secured to the wall. An ornamental stamped sheet-copper band is then slipped on between the heads to conceal the real rigid attachment. The lugs of the band should be attached to the wall by expansion bolts. This arrangement gives a pliable joint. The corrugations in this leader, however, should run lengthwise, and all the joints should be slip joints. Iron supports should never be used in or against a stone wall, because they rust and stain the masonry.

57. Offsets in leaders should always be avoided. It is common practice to offset the leaders at stone, brick, and terra-cotta moldings, but in good practice they should be fitted up straight and plumb, the necessary holes being cut through special blocks formed in the molded courses for the passage of the leaders. It is customary to discharge sheet-metal leaders into a cast-iron pipe, which is continued up about 4 or 5 feet above the surface of the ground, the object being to prevent the leader from being flattened or otherwise injured. Rectangular leaders should, for the sake of appearance, connect at the bottom with a rectangular cast-iron pipe, and not with a round pipe.

58. Size of Leaders.—The proper size of leaders, of course, will vary with the climate, the amount of rainfall, and the manner in which the gutter catches the water; but a good safe rule for every-day practice is to allow 1 square inch of sectional area of conductor pipe for every 75 square feet of flat-roof area. No leaders, however, should be less than 2 inches in diameter, and even this size should be used only for small roofs, such as those over bay windows, small porches, etc.

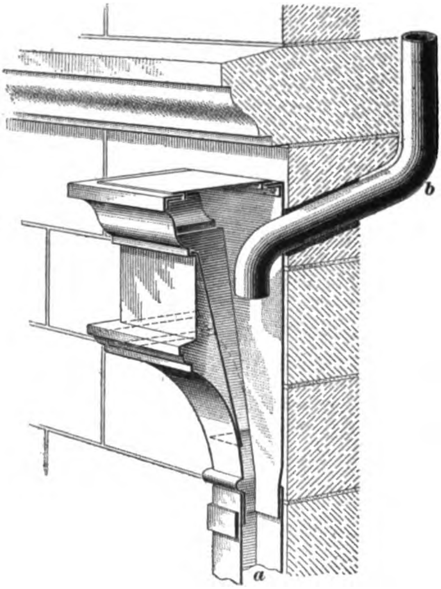


FIG. 46

The *underground pipe* (often drain tile), into which the leaders discharge, should not be less than 4 inches, inside diameter, and they need not be more than 8 inches in diameter for any work where the roof area is less than 1 acre. In measuring the watershed of pitched roofs, calculate the projected or horizontal area—that is, the area on the plan.

59. Rain-water heads, sometimes called *conductor heads*, are often employed on the top of a leader, and treated as an architectural feature by forming a graceful outline to the receptacle for the gutter discharge. Two or more leaders may deliver into one head, as the conditions may require.

Fig. 46 shows a conductor head in section. It is set on top of a rectangular, corrugated, sheet-metal leader *a*, which should be securely fastened to the wall with a band on top. The lower end of the head slips into the conductor, and the top is fastened to the stone wall with expansion bolts or other fasteners. A brass angle should be fitted inside the rim. The roof gutter empties into the head through a large lead or copper pipe *b*, which runs up a chase in the back of the wall, thus concealing it from outward view. The top of the head should be covered to prevent birds from building their nests in it, or in the pipe *b*. The proper position for a rain-water head should be carefully shown on the elevation, as mechanics are prone to set them at the handiest place, without reference to the architectural treatment of the façade. All rain-water heads should be lined inside with a tapering box, to extend below all moldings and prevent possible leakage, and also to prevent noise during heavy rains.

60. Strainers.—Every leader opening in a gutter should be provided with a strainer to hold back leaves, twigs, etc., and to prevent birds from building nests in the leaders. The best strainers are those constructed of a ball or hemispherical form, like those shown in Figs. 37 and 39.

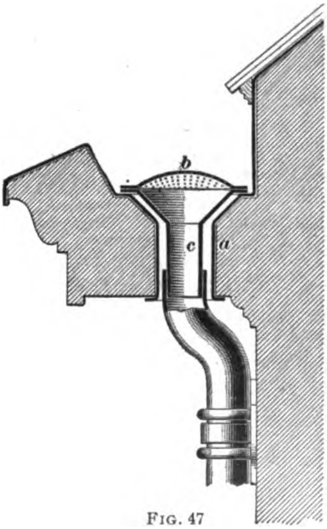


FIG. 47

For ordinary purposes, where the roof water flows to waste, wire ball strainers, put together something like bird cages, are generally used. But in cases where the roof water is gathered into cisterns or tanks and stored for domestic use, the strainers must be very close in order to prevent pieces of leaves, etc. from being washed down into the cisterns. Such vegetable matter soon decays and pollutes the water. The strainer *b*, Fig. 47, is specially made for this service. It has a very large straining area, which is closely perforated with holes not larger than $\frac{1}{8}$ inch.

61. Gutter connections to leader pipes are very important details and should be carefully considered. The offsets necessary for cornice and overhanging gutters should have a good grade from gutter to leader, and should be composed of easy bends—not sharp elbows. Owing to the fact that leaders are liable to freeze, it is advisable to provide outside gutter connections with a tube, as shown at *a*, Fig. 47. This tube is soldered to the gutter lining on top, and may be flanged over the face of the soffit of the cornice at the bottom, as shown, thus forming a water-tight channel through which the leader pipe *c* passes. If the leader should freeze and burst between the gutter and the soffit of the cornice, the tube *a* will prevent the water from leaking into the cornice, which, if made of wood, will soon cause the decay of the material.

When copper leaders connect with tin-lined gutters, or vice versa, it is advisable to make the gutter tube *c*, Fig. 47, of the same material as that used for the gutter lining. If different kinds of materials are employed for this purpose, a galvanic action may occur between the two metals, which will hasten corrosion. The connection of the gutter tube to the leader is made with a slip joint.

62. Leader Cut-Off.—When the leaders discharge into cisterns or tanks, it is advisable in all cases to provide them with cut-offs, so that the water may be discharged to waste or into the cisterns, as desired. Every roof is foul, to a certain extent, with decaying vegetation, bird lime, etc., and all this matter is washed off during the first few minutes of a rain storm. If a cut-off is not used, the dirt, of course, goes into the cistern. It is customary to leave the cut-off free from rain to flow to waste until the roof is supposed to be washed clean, then it is turned so that the remainder of the water will flow into the cistern.

There are many kinds of cut-offs on the market. Some are made to be operated by hand, while others are intended to operate automatically, when a certain volume of rain water has passed through to waste. The latter are preferable, if reliable, because the hand cut-off is likely to be neglected.

DOMES AND LANTERNS

63. In many parts of Europe, it is customary to cover domes, lanterns, cupolas, etc. with sheet lead; but, in the United States, owing to the great variations in temperature that are encountered, it is necessary to use a metal that is better adapted to withstand the unavoidable expansion and contraction.

Sheet copper or galvanized iron are the best metals for use in countries where excessive changes in temperature occur. The latter, however, is not durable enough for covering domes, lanterns, or cupolas, and, consequently, sheet copper is generally employed.

There are different methods of covering domes, but the following four may be considered preferable: namely, *plain* or *smooth*, *ribbed*, *paneled*, and *metallic shingle* or *slate coverings*.

64. Smooth covering is usually put on domes in a manner similar to that employed in flat-roof covering, with flat locked seams, each sheet being well tied down with strong cold-rolled copper cleats. If the dome is large, the ordinary flat sheets about 20 in. × 28 in. are generally used, the curvature of the dome being so slight that the soft copper will easily adapt itself to the shape. When the dome is small, however, each sheet must be blocked out to the proper curve, so that the covering, when finished, will have a neat smooth appearance and be free from buckles. The greatest objection to locked-seam covering is the liability to leakage, chiefly through the seams, on the nearly horizontal parts of the dome. The solder will spoil the appearance of the dome if the copper work is allowed to retain its natural color.

65. Ribbed Surface Covering.—To avoid leakage on domes by the effects of expansion and contraction, and to prevent any solder from discoloring the copper work, some form of ribbed covering is employed. This requires the use of a standing or a roll seam, as the character of the building may demand.

The space between the standing seams or rolls should not be more than 2 feet wide, and the sheets should not be more than 4 feet long. They must be securely supported from the top edge, preferably with heavy cold-rolled copper cleats.

It is advisable in all first-class sheet-metal roofing to avoid driving nails through the sheets at any point. The sheets are thus permitted to freely expand and contract without tearing the metal.

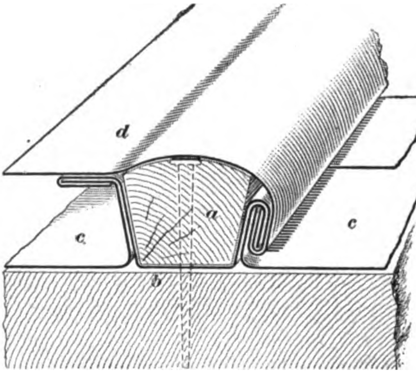


FIG. 48

An excellent roll seam is shown in Fig. 48. The batten, or roll strip, *a* is nailed down over a long cleat strip *b*. The sheets *c*, *c* are then sprung in between the rolls and the cleat strip is doubled over the upstand. The roll cap *d* is then put on over the roll, and locked into the cleated upstand as shown. The roofing sheets, cleat strips, and roll caps are thus all locked together and made water-tight, and yet are free to expand and contract individually. The batten nails combined with the outward curvature, which the sheets *c* must necessarily have, will prevent a gale from rattling or loosening the sheets.

66. Horizontal Seams.—The best form of horizontal seam that can be made on domes is shown in Fig. 49. A strong cold-rolled copper cleat strip *a* is nailed to the roof with flathead brass or copper nails; and the top edge of the under sheet, the bottom edge of the upper sheet, and the cleat strip are all locked together as shown. With this arrangement, each sheet can expand and contract lengthwise without affecting the stability of the support. If the sheets are simply lapped at this seam, the wind will get underneath and raise them in the middle, thus opening the seams and making them visible from the street.

When it is required to set the rolls more than 2 feet apart, it becomes necessary to support the sheets between the rolls. This is accomplished in different ways. The sheets may be laid so that the horizontal locked seams will be about 18 or 20 inches apart, the rolls being perhaps 4 or 5 feet apart. When very large sheets must be used, however, *secret tacks a*, Fig. 50, are riveted and soldered to the back of the sheet *b* at intervals, which will allow about 2 or 3 square feet to be supported by each tack. As the sheets are being put on, the tacks are pushed into long, narrow holes in the woodwork, and then pulled through and nailed to the inside of the dome as shown.

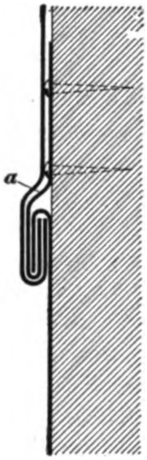


FIG. 49

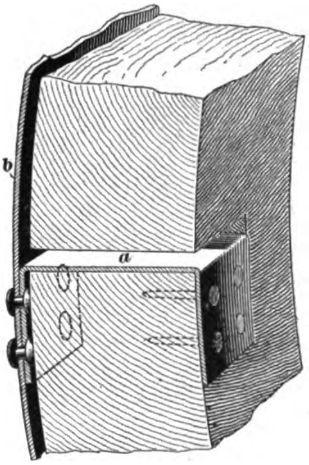


FIG. 50

67. Location of Rolls.—In locating the position of the rolls, it is necessary to consider the general construction of the edifice, both above and below the dome. The ribs or rolls should not be put up to suit the standard stock sizes of copper sheets, but they should be located to harmonize with the leading architectural features of the composition.

For example, consider the dome of the cupola, or lantern, shown in Fig. 51. The ribs here divide the dome surface into equal sections, two sections being immediately over each window opening. Every second rib is directly in line with the center line of a column. When the sheets are drawn closely together at the top, as shown, the ribs are usually tapered, being wider at the bottom than at the top; but when there is considerable space between the top ends of the ribs, they are usually made the same width throughout their length.

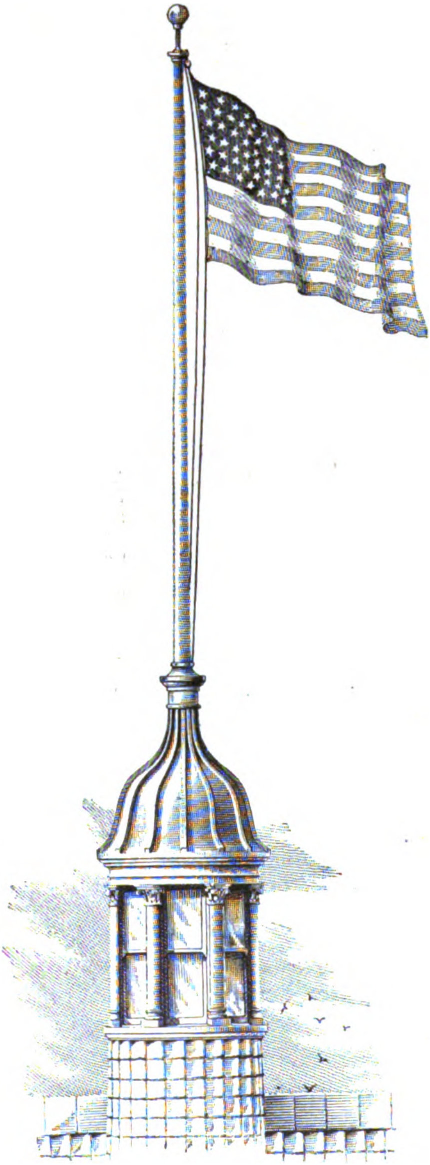


FIG. 51

68. The Paneled Dome.—A paneled dome is shown in elevation in Fig. 52. The lantern under the dome is octagonal in form, with a window *a* in each side. The dome, however, is round in plan with a panel *b* located directly over each window. The top of the dome is surmounted by a statue, the base of which is shown at *c*. A vertical section through the dome and a few details are shown in Fig. 53. The elevation, Fig. 52, shows ribs *d*, *d* running from the cornice of the lantern up to the base of the statue, but these may be omitted.

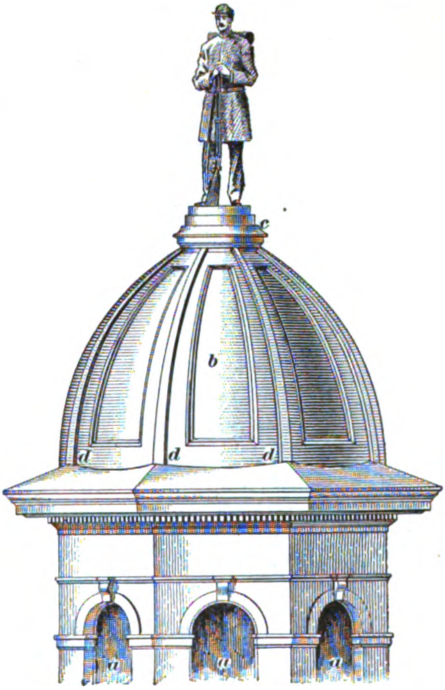


FIG. 52

At *e* in the detail, Fig. 53 (*a*), is shown a method of securing the panels in place without ribs, when there is no panel molding. The panels are simply double-seamed with cleat strips to the stile strip *e*, as shown. But where ribs are desired on the stiles, or when moldings must be run around the panels, the connections may be made as shown at *f* in the same detail. If the panels have a larger surface than 3 or 4 square feet, secret tacks may be employed to advantage, as shown by dotted lines. A detail of the top molding of each panel is shown in view (*b*), and a detail of the bottom and the wash over the corona of the lantern is shown in (*c*). These seams are all made in the shop, being locked and thoroughly soldered at the back, with the exception of *i*, which is made in place and is thoroughly cleated and soldered. The statue base *c*, Fig. 52, is slipped down over a sheet-copper collar, and is fastened to the top of the dome with four bronze bolts, which are threaded close under their heads to make a permanent water-tight connection. Fish-plates and nuts are employed underneath in the ordinary manner.

69. Flagpole Flashings.—Flagpole flashings, and those around all other forms of movable finials, require much attention to detail, as they must be made water-tight, and remain water-tight under peculiar conditions. Every flagpole sways more or less, according to its strength, the pressure of the wind, etc., and, therefore, a rigid flashing at its base cannot be durable. The liability of the pole to "settle down" is another matter to be considered. On this account, it is advisable to use *slip joints*, or telescope flashings, which

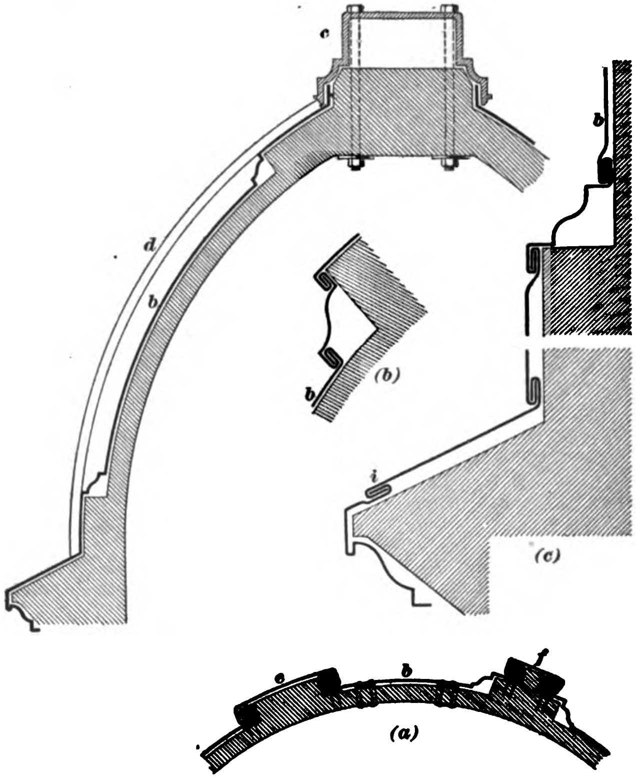


FIG. 58

are provided with enough clear space, or "play," to allow the pole to move or sway in any direction without touching or affecting the sheet-metal covering of the dome. A good arrangement is shown in Fig. 54, which is, in fact, a detail of the intersection between the flagpole and the cupola shown in Fig. 51. The rolls of the dome finish inside of the bead *a*. The copper work finishes around the top member *b*. A bonnet *c*, made of sheet lead weighing 8 pounds per square foot, encircles the pole and covers the member *b*. The top of the bonnet is "dressed" close into a small groove in the pole, which is cut just deep enough to allow the lead to finish flush, a bed of red and white lead being used to make the connection water-tight. The bonnet is nailed to the pole with a ring of 1-inch, pointed, flathead copper nails, which may be concealed with a bead *d* if desired. The lower edge of the bonnet overhangs the block *b* and forms an open lap joint around the top of the copper. The top of the block *b* is well greased, and the bonnet is free to slide as the pole sways.

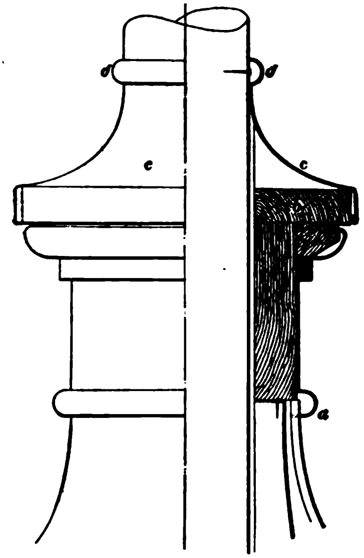


FIG. 54

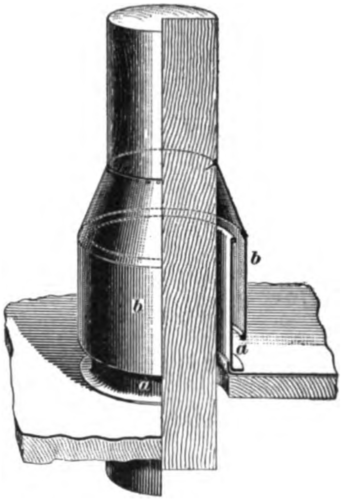


FIG. 55

When the pole intersects a flat roof, a plain slip-joint connection, like that shown in Fig. 55, may be used. A cylinder, or upstand, *a* is soldered to the roof. A sleeve *b* overhangs the upstand and is nailed to the pole as shown, a space being provided on each side of the upstand to allow the pole and its flashings to move in any direction.

70. Flagpole Cap.—The top of a pole should always be protected either by a sheet-metal flashing or by a cap. A flagpole cap, with regulation ball, is shown in Fig. 56, which is a detail of the cap shown in Fig. 51. A brass casting *a* fits snugly over the top of the pole and is fastened to it with brass screws. An eyebolt at the left holds the flag pulley. A piece of brass tube *b* joins the cap to a brass spud *c*, which is soldered to a seamless copper ball.

This style of cap not only protects the pole from the weather, but provides a suitable pulley connection, and gives an artistic finish to the apex of the flagpole.

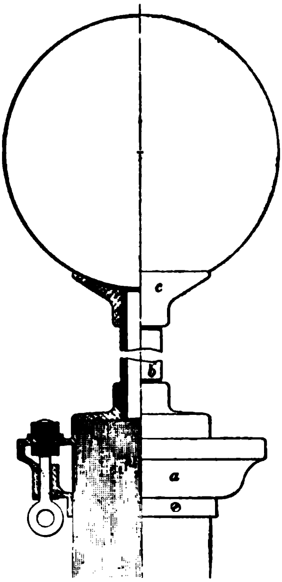


FIG. 56

CRESTINGS

71. Sheet-metal crestings are of varied design and construction; they can, in fact, be made in any design that is adapted to stone or terra cotta. The most important features to consider in crestings are the method of support and the connection to slate or shingle roofs. Ordinary crestings are so constructed that the nail heads in the top course of slates are left exposed to the weather. This is a mistake, as rain will certainly follow the nails and cause slight leakage, which may not be visible, but which, nevertheless, hastens the decay of the timber and rusts the nails.

72. Attachment.—Fig. 57 shows a method of attaching sheet-metal cresting on ridges and hips in such a manner that all nail heads are concealed. Channel strips *a*, *a* of strong sheet metal are bent to the shape shown and nailed on the roof close to the ridge pole. The top course of slates is then pushed in the channel and fastened with the nails *b*, *b*, as shown. The cresting *c* is then sprung over the channel strips and the lower edges are closed into them, thus locking the cresting and the channel strips together. The edges at *d* are locked together to prevent wind from lifting or rattling the cresting. When the ornamentation projects more than 9 inches, it is advisable to nail suitable lookouts on the top of the ridge pole.

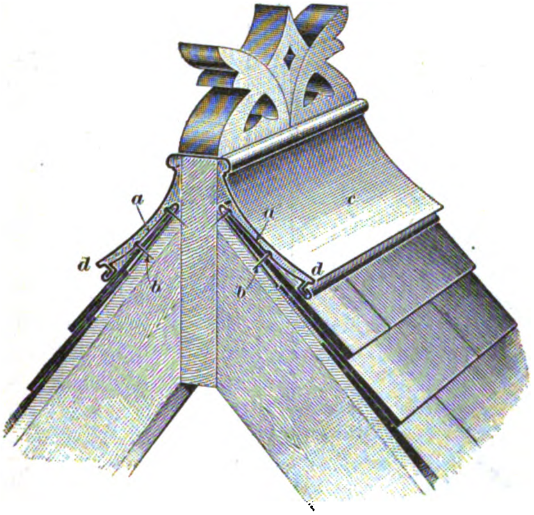


FIG. 57

The joints in crestings should be made in a manner similar to that already prescribed for cornices.

FINIALS

73. Finials less than about 7 feet in height are usually built in the shop to conform with the drawings of the architect, and are taken to the building and erected in one piece. Larger finials, however, are usually set up in two or more pieces, according to their height, weight, and form. All the joints should be double-seamed and soldered inside, in the same manner as cornice joints.

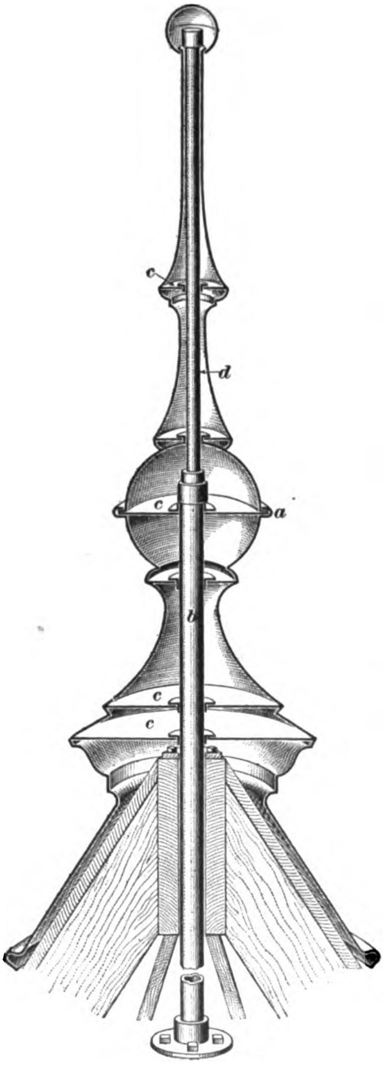


FIG. 58

Finials having round members are built up from either *spun* or *pressed metal*. Spun metal is preferable. Other forms are built together in different ways, according to the shape of the members.

All finials should be securely supported to prevent them from sagging, and braced to prevent them from leaning out of plumb. The system of supporting and bracing required will depend on the shape and the size of the finial. In some finials, a straight iron pipe alone will form a satisfactory support, while others must be provided with lookouts, like cornices, and often with braced framework. Fig. 58 shows a simple and efficient method of supporting a long narrow finial on the peak of a conical roof. This finial is taken to the building in two pieces, and is joined together in position, with a lock seam *a* around the ball. A 2- or 3-inch galvanized-iron pipe *b* is securely supported and braced to the framework of the roof. Horizontal partitions *c*, *c* are soldered to the inner surface of the finial and snugly fit the

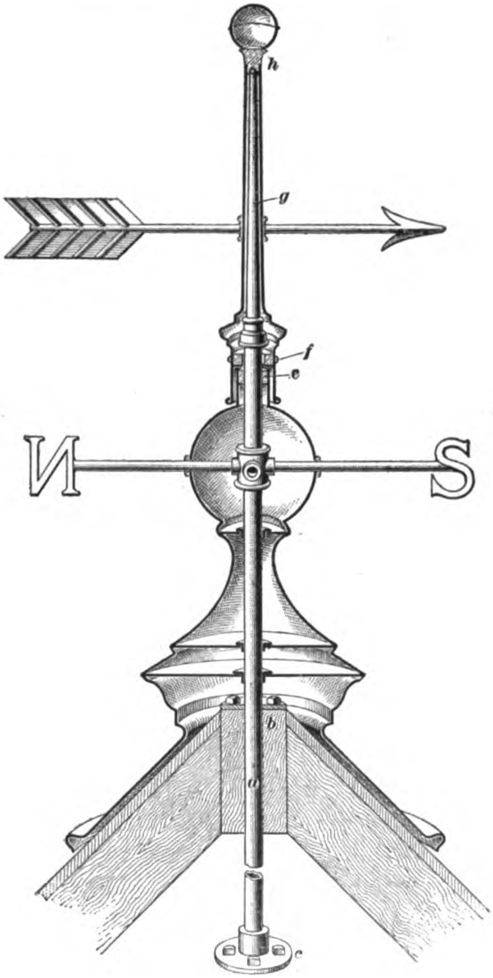


FIG. 59

iron pipe; these form braces and keep the finial straight. A few vertical gussets are soldered inside the ball to strengthen it vertically. A threaded pipe coupling is soldered inside the top ball so that this ball may be securely attached to the top of the pipe *d*.

74. Weather vanes are a class of finials provided with a movable part that rotates on a vertical axis by the force of the wind. They are employed to show the direction in which the wind blows and consequently are provided with the letters N, S, E, W, located respectively north, south, east, and west of the axis of the finial. These letters are secured to the stationary part of the finial. An arrow, or some other form of indicator or pointer, is also employed in the construction; this is attached to the movable part of the finial. Fig. 59 is a vertical section through a simple weather vane. It is similar to the finial shown in Fig. 58, except that the top part is made to rotate. An iron pipe *a*, which rests on a solid footing, passes vertically through the apex of the roof. A collar at *b* and a cross-beam at *c* rigidly secure the pipe and keep it plumb. A special fitting, called a *double-cross*, receives the arms that support the four letters already mentioned. These arms also reinforce the ball. The top of the stationary sheet-metal work is riveted to a brass ring *e*. The bottom of the movable part of the vane is bolted to a brass ring *f*. These rings keep the copper in proper shape at the slip joint. The lower end of a tapered steel bar *g* is screwed into the reducing socket on top of the pipe. The top end of the rod is tapered off to a sharp pivot point, and works in a brass socket *h*. This rod must be free and clear from the copper shell around it, so that the arrow may swing around to face the wind with the least possible resistance. The movable section must be carefully balanced; it should be so sensitive that a man can move it with his breath. The ring *f* is located under the reducing socket, and prevents the movable section from being thrown off in a storm.

75. Interior Sheet-Metal Work.—Sheet metal is seldom used in the interior of buildings except for covering walls, ceilings, etc., and even then it is only used for a cheap grade of work, so as to obtain the most elaborate effects at a very low cost. The principal items for consideration are the methods of fastening the sheets to the building and the selection of a design from manufacturers' stock.

It is customary for the sheet-metal worker to nail furring strips on the ceiling and walls at such distances apart as will conform with the design stamped on the sheets, but in no case should they be more than 1 foot apart. In selecting the furring strips for ceilings, particular care should be taken to allow for sufficient depth for any electric-wire conduits or gas pipes. The sheets are laid on the walls to overlap one another, and the nails are driven through the ornamentation in such a manner as to apparently form a part of the decoration. The lap seams should all be laid so that the light from the windows will shine against the edges of the sheets and thus avoid shadows, which would indicate the location of the seams.

All sheet-metal wainscoting, baseboards, dados, and chair rails, and, in fact, all ornamental sheet-metal work that is likely to be damaged by rough treatment, should be "pugged" behind with Portland cement.

All heavy moldings and cornices should be backed by lookout brackets cut to the proper profile. All wood backing should be covered with asbestos sheets when it is desired to form a fireproof enclosure. Plain black-steel sheets should be dipped in iron oxide and linseed oil before they are put up. In all damp places, it is advisable to use bright tin or zinc; the latter is preferable.

MATERIALS USED IN SHEET-METAL WORK

76. Black iron or steel is used only for the very cheapest roofing and siding, also for interior decoration or fireproofing. No. 26 gauge is generally used. In all cases, the sheets must be protected against corrosion by metallic paint or other suitable coatings.

77. Galvanized iron is used for sheet-metal siding, cornices, plain brackets, plain trusses, plain modillions, corrugated roofing, etc. No. 26 gauge metal is generally used throughout. No. 24 metal, however, is preferable for all large moldings.

78. Zinc is seldom used for covering buildings in the United States. But owing to the fact that it can be pressed into ornaments better than iron, it is employed for ornamental trusses, brackets, modillions, rosettes, festoons, etc., in galvanized sheet-metal fronts, and for balusters in balustrades. All zinc and galvanized sheet-metal work may be soldered on the face. All galvanized ironwork should be painted with a zinc body paint.

79. Cold-rolled copper is always used for copper cornices, moldings, columns, and all plain surface work that is to be formed in copper. The weight of the copper should not be less than 14 ounces, and it need not be more than 20 ounces on the very best class of buildings; 16-ounce copper is commonly used on good work, while 18-ounce is reserved for heavy moldings. All cold-rolled copper work should be fastened in place with brass or copper nails, screws, or bolts, as the conditions may require. All soldering should be concealed. When it is desired to paint copper work, the metal should be tinned all over the face to prevent the copper from coming in contact with the paint.

80. Soft-rolled copper is often called *hot-rolled copper* and is used for lining gutters, valleys, etc., and for pressed or hammered ornaments. The weight generally specified is 16 ounces, and 18 or 20 ounces on such work as may be subject to much wear and tear, either by expansion and contraction or by rough usage.

Soft copper, tinned on both sides, is best adapted for gutters and all other work that depends on solder for tightness and strength. Copper cleats should always be cold-rolled.

81. Soldering.—Sheet-metal seams should be soldered very slowly, because it takes time to properly sweat a seam, and very hot, well-tinned, soldering irons should be used. Any mechanic discovered "rushing" a seam or hastily skinning it over with solder should be immediately discharged and all his work should be resweated by a careful man, as the durability of sheet-metal work depends chiefly on the soldered seams.

Resin should be used as a flux for all tinned copper, and chloride of zinc for all plain copper, galvanized iron, and zinc. Raw muriatic acid or sal ammoniac should not be used as a flux.

82. Tarred roofing felt should be laid under all sheet-metal roof work and gutters, to protect the under side of the metal from moisture and deleterious vapors, also to form a soft protecting cushion for the metal.

83. Woodwork.—All woodwork under sheet-metal roofing should be smooth and evenly laid and properly graded by the carpenter. Nail heads, knot holes, and sharp corners are detrimental to sheet-metal work.

MILL DESIGN

SITE AND ARRANGEMENT

PRELIMINARY CONSIDERATIONS

INTRODUCTION

1. The requirements of the modern factory building are many, and demand the careful attention of the architect in their planning and construction. There are probably more rules and regulations imposed by the state and local governments and by the Insurance Underwriters, regulating the construction of this class of buildings, than for buildings of any other character.

The laws imposed by the governments under whose jurisdiction the building is to be erected, are framed manifestly for the protection of the health and safety of the occupants of the building, and so as not to jeopardize their lives in case of fire or panic, or the lives of those engaged in the attempt to save the structure and prevent damage to the adjoining property.

The Underwriters, or the Association of Insurance Companies, have compiled numerous rules and regulations of which the architect planning the building must take cognizance if he desires to secure a reasonable rate of insurance on the building and its contents for the owner. Not only do these rules and regulations deal with the structural design of the building, but they consider the apparatus for protection in case of fire, and such installations as the electric

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wiring. The architect must be familiar with all these requirements in order to intelligently and practically design industrial plants.

There are, also, many factors essential to the utilitarian and economic operation of the building entering into the design of the modern factory, to which the architect must devote careful study. Among the most important of these are the economic receiving, shipping, elevation, and transportation of merchandise; the proper and adequate lighting of the building; the location and planning of the power plant for the building, together with the engineering problems of construction, which include the design of the floor, columns, and walls for the loads to which they are subjected.

CLASSIFICATION OF FACTORY BUILDINGS

2. Classified according to their construction, factory buildings may be divided into three types, which, for convenience, may be designated as *first-*, *second-*, and *third-class buildings.* A similar division to this is also frequently made by the state or municipal laws for the regulation of the construction of factory buildings.

3. First-Class Buildings.—Buildings of the first class are those in which the walls, floors, columns, girders, beams, partitions, and roofs are of stone, brick, terra cotta, concrete, steel, iron, and such other fireproof materials as have been proven to be efficient. Buildings of this class may be considered as constituting an entirely fireproof building, which means that while the contents of the building may burn, the building itself will remain intact, unless subjected to the severe action of a prolonged conflagration.

4. Second-Class Buildings.—Buildings of the second class are considered to include what is known as slow-burning, or the typical factory-construction, type, in which all posts or girders must be of heavy and massive timber, and the floor construction at least 3 inches in thickness, and of solid planking. In buildings of the second class, while it is permissible to use combustible materials, they must be of such sizes and of such slow combustion that the security of the building will be insured for a reasonable time after the conflagration has commenced. It is usual, therefore, in this class of building, to limit the size of the wooden posts to not less than 8 inches square, though their strength may be greatly in excess of the load they are required to support, and girders and beams are used whose least dimension is 6 inches or more. In buildings of this character, it is frequently necessary to use steel beams and columns in order to obtain the strength for the great floor loads to which these members are liable to be subjected. When such steel or iron columns are used, however, they must be fireproofed, because even though made of incombustible material, they would not have the same endurance in a fire as have heavy wooden girders or posts, and their failure would precipitate the fall of the floor. Wooden girders and posts, even when charred part way through, have still sufficient strength for the support of the load for which they were designed.

5. Third-Class Buildings.—Buildings of the third class are not particularly recommended for the construction of factory buildings, for the floors of these may be of the ordinary joist and finished floor construction. Such buildings are readily ignitible and burn rapidly, not only because the timber work in them is light, but because of the numerous air spaces that exist between joists and in the furring of the walls. No building with air space surrounded by combustible materials can be considered as slow burning.

FACTORY PLANNING

6. Considerations in Planning.—The outline of the building is determined by the site, and owing to irregularities in the site generally purchased for manufactory purposes, it is frequently difficult to properly design buildings of this character. The factors that probably influence the design mostly, after the location of the column supports, and consequently the spacing of the windows has been determined upon, are the stairways and elevators.

In many cases, these are the only subdivisions of the main-floor plans, and in order to comply with the rules and regulations of the local or state governments, and of the Underwriters' Association, they demand primary consideration. The stairways must as well be easy of access, while the elevators must be conveniently located for the delivery and receipt of goods from the first floor of the building.

Another factor that is likely to enter into consideration of the design is the toilet rooms, which must be placed against an outside wall, and convenient to any part of the floor.

ARRANGEMENT OF STAIR TOWERS

7. The Enclosed Stairway.—The important consideration in the planning of factory stairways is to provide a quick, easy, and safe egress for the occupants in case of fire. While it is necessary to have good liberal stairways for communication between the floors, this is not such an important feature in factory design, from the fact that there is little travel of employes between the floors, in a modern factory, as each individual's work is usually apportioned to him and confined to a particular location, and therefore does not require him to be on different floors during the day.

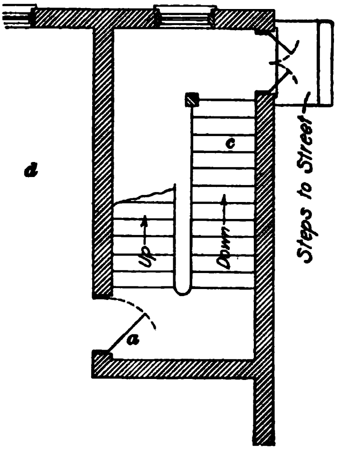


Fig. 1

The common type of factory stairway is that designated in Fig. 1. This shows a brick-enclosed stairway with the doors entering it direct from the factory. Such a stairway enclosure as this should have tin-lined doors as at *a*, which fireproof the opening. Even then the security of a stairway of this character is not certain, from the fact that these doors may be left open, and are open to the stairway during the egress of the occupants. With a severe fire, therefore, on any floor, such a stairway is likely to be filled with smoke to suffocation, and liable to ignition from the door openings. It can therefore only be regarded as a makeshift for a fire-escape, or fire-tower. It is also well, in the design of such a stairway, to observe that the doors always open outwards, and not only this, but that they open with the tide of people coming down the stairs. For instance, in the figure the door *a* is opened correctly, but if the flights of steps marked *down* and *up* were transposed, then people coming down the flight *c* would press against the door at *a* and prevent the people in the room *d* from getting out to the stairs and hence to safety.

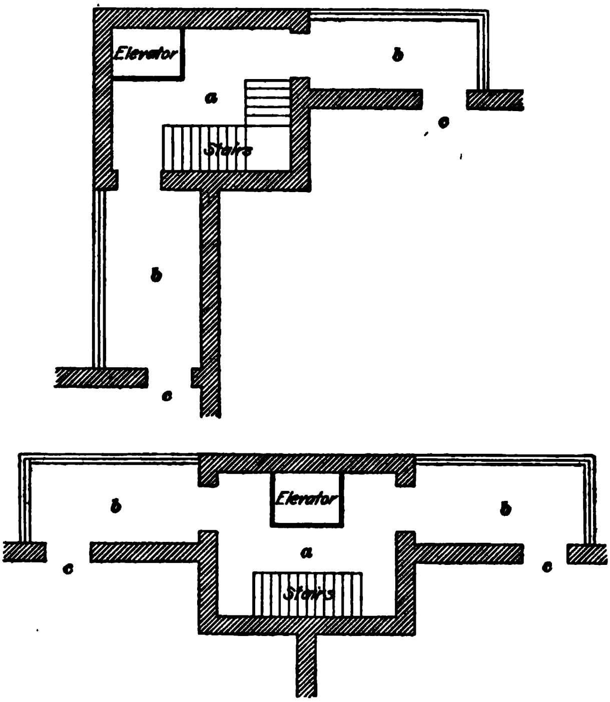


FIG. 2

8. Enclosed Fire-Escape, or Stair Towers.—Various designs for brick-enclosed stairways of factory buildings have been recommended at different times by the insurance companies. Two of these designs are designated in Fig. 2 and show the elevator included, as well as the stairway, in the tower.

A study of these plans will show that there is no direct communication from the building to the stair tower, and that the only way by which the stair tower may be entered is through an open balcony, which communicates with a door in the side walls of the building, at each floor. The brick-enclosed stair tower is shown in the figure at *a*, the open galleries at *b*, and the door of egress from the factory at *c*. By means of this arrangement, the occupants of each floor can, in case of fire, go through the door in the side wall, on to the open balcony, and into the fire-tower, thence down stairs or elevator to the ground floor and safety. Because of the openness of the balcony, which is surrounded with a strong rail, and partially covered by the gallery above, the fire could hardly be sufficiently great on any floor to make it untenantable, and no smoke or flames could communicate with the fire-tower.

9. Vestibule Fire-Tower Stairway.—While the arrangement just described is rational, the fire-tower is of such dimensions as would ordinarily preclude its use in the modern building where ground space is valuable and every inch of surface must be economized.

The best possible design, therefore, for a fire-tower is that indicated in Fig. 3. This construction is known as the **vestibule fire-tower,** and from the plan it is seen that this combines safety and utility in a small amount of space. The opening marked *a* in the plan is always open to the weather, and the floor of the vestibule is usually concreted and graded to a drain that connects with the rain conductor of the roof at *b*. By this arrangement, a well-protected line of travel is obtained between the stairway and the buildings on each floor, the occupants of the building being protected by the parapet wall and iron railing, as indicated at *c*, *c*. To this vestibule from the factory a tin-lined, or fireproof, door must be provided, so that after the people have left one floor it can be cut off from the vestibule.

In the construction of all fire-towers, their walls must be carried by means of parapet walls at least 3 feet above the roof of the building, and the roof over them must be constructed of fireproof material.

When it is required, fireproof windows may be used in the walls of brick-enclosed fire-towers. These windows may be constructed of sheet metal and glazed with wire glass. If it is not possible to use such windows, a skylight may be built over the top of the tower, but this skylight must be constructed of sheet metal, or other non-combustible material, and glazed with wire glass.

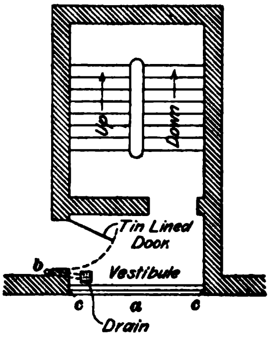


FIG. 3

10. **Number of Fire-Towers.**—The number of tower fire-escapes required for factory buildings of either the first, second, or third class, may be established according to the number of stories in height of the building, and the floor area, in square feet, for each floor; that is, for buildings of the first class, three or four stories in height, having one tower, the floor area of any floor may be as much as 20,000 square feet, while if the height of the building of the same construction is made twelve stories, the floor area should only be 6,500 square feet.

Where two tower fire-escapes are incorporated in the plan, a building three or four stories in height may contain as many as 25,000 square feet in the area of one floor, but if the building were increased to twelve stories, the floor area of each floor should not exceed 15,000 square feet.

In buildings of the second and third classes, a greater number of tower fire-escapes should be provided, and it is good practice to supply one tower fire-escape in a three-story building of these classes for a floor area not exceeding 10,000 square feet, or two tower fire-escapes should the floor area not exceed 15,000 square feet. In buildings of this construction, of from four to six stories in height, the floor area should not exceed, for one tower fire-escape, from 6,000 to 3,500 square feet of floor area in each floor, while with two tower fire-escapes the maximum floor area is from 12,000 to 8,000 square feet.

11. Location of the Fire-Tower.—Where two tower fire-escapes are used in a building, they must not be located near to each other, the purpose always being to provide a second egress in case of one being cut off by smoke or flame.

In small buildings of considerable height, it is sometimes difficult to so arrange the plan as to provide two stairways at extreme ends or corners of the building. In a case like this, it is frequently necessary to extend balconies along the side of the building, entering the fire-tower at some more distant point.

ELEVATOR SHAFTS

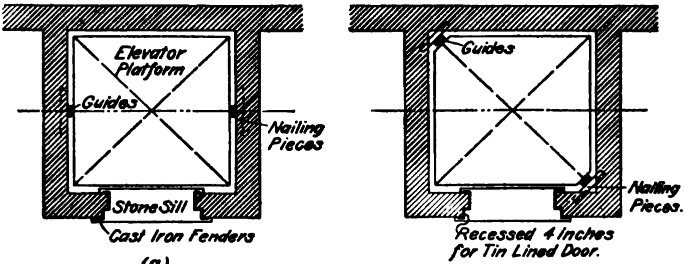
12. Location of Shaft.—In all factories of two or more stories, an elevator is a necessity for the economic transmission of goods from one floor to another. While in some instances the elevator is run through hatch openings in the floor, without being enclosed in brick walls, it is not good practice, for the openings through the floors make possible the rapid communication of flames and smoke in case of fire, even when provided with an automatic closing hatch. Elevators are therefore generally built in an elevator shaft, the walls of which are constructed of good hard brick and made from 12 inches to 18 inches in thickness.

13. Elevator Doors and Openings.—In building elevator shafts, it is necessary to provide door openings at each floor, the openings being protected with tin-lined fireproof doors. These doors may be either folding or sliding doors, it usually being considered best to provide a sliding door that will automatically close when a certain temperature has been reached in the building. It is not always possible, however, to provide sliding doors, from the fact that where the elevator shaft projects out into the room and the door opening is wide, there is no wall space on which to fasten the track. Customarily, in each door opening, there is also provided a heavy stone or cast-iron sill. As in many states the law requires some automatic, or folding, lift gates for elevator openings, it is the practice to project this sill inside of the shaft at least 4 inches, in order to provide a bearing and protection for such gates.

14. Construction of Openings.—The openings in the brick walls of an elevator shaft are constructed ordinarily with rowlock brick arches, and from the fact that the openings are usually wide, and little jamb is left on each side of the opening, it is necessary to build 1-inch round iron rods in the arch above the opening, these tie-rods being furnished with washer plates at each end.

The jambs of all openings in the elevator shafts should be protected with cast-iron fenders made of about ½-inch metal, and so constructed as to return about 4 inches on each face. These jambs are provided with heavy wrought-iron anchors, which are built into the brickwork in the process of construction.

15. Freight Elevators.—Freight elevators are either corner-guided or side-guided, the preference being for the latter, as they are more easily constructed and adjusted, and during the construction of the elevator shaft it is usual to build into the brickwork blocks of wood about the thickness



(a) (b)

FIG. 4

of a brick and of sufficient length for the attachment of the guides. These are cut wedge-shaped on the ends, so as to hold more firmly in the brickwork. A diagrammatic plan of a side-guided and corner-guided elevator is illustrated in Fig. 4 (*a*) and (*b*), respectively.

Owing to the fact that it is necessary to have considerable hoisting mechanism, at the head of the elevator shaft, the shaft is extended above the roof, sometimes as much as 5 or 6 feet, for the minimum height from the elevator platform at the top floor level to the under side of the beams carrying the mechanism is about 16 feet, and the sheaves carrying the rope and other mechanism at the top of the shaft require several more feet.

16. Elevator-Shaft Windows.—Frequently, elevator shafts are lighted with windows. Where such windows open into the building, they must be constructed with metallic frame and wire glass; but where they open outside of the building it is not necessary to do this. Where elevator shafts are lighted from the top, metallic skylights glazed with heavy glass should be provided. It is not considered such good practice to use wired glass for this glazing, the idea being that in case of fire, as each floor is cut off from the elevator shaft with fireproof doors, vent may be had from the skylight at the top of the shaft when the glass is broken, and some of the municipal and state laws stipulate that the skylight at the top of an elevator shaft shall not be less than two-thirds the area of the shaft.

As there is some mechanism on the bottom of the elevator platform and at the foot of the shaft, it is necessary to sink the shaft at least 3 feet below the basement floor level, provided that the elevator runs to the basement floor.

TOILET ROOMS

17. Location of Toilet Rooms.—In designing factory buildings where a great many people are employed, the question of toilet accommodations is a very necessary consideration.

After the location of the toilet room has been decided on, and it should be placed as centrally as possible to the floor area, the number of closets should be determined. It is usually found sufficient accommodation if one closet is allowed for twenty people. In planning the toilet room, it is essential, and generally required by law, that the room shall be located on the outside wall, so that windows will open directly into it. If the partitions between the compartments only extend part way toward the ceiling, it is not necessary that each compartment of the toilet room containing a closet should have a window. For instance, referring to Fig. 5, which is a typical arrangement of factory toilets, it is necessary only to provide the window opening into the outside space surrounding the enclosures around the closets.

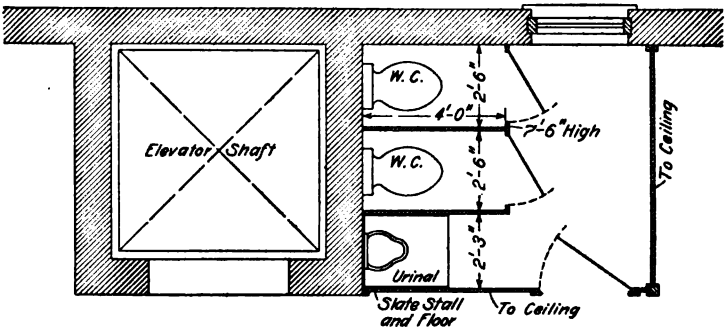


FIG. 5

18. **Material Used for Partitions.**—The partitions of both the compartments and the toilet room are, in factory construction, usually built of $1\frac{1}{8}$-inch, yellow-pine, tongued-and-grooved, beaded ceiling, the corners of the partition being braced with 4″ × 4″ stop-chamfered yellow-pine posts rabbeted to receive the ceiling. In no instance should the partitions be constructed with an enclosed space or concealed work. For hygienic reasons, it is always advisable to provide toilet rooms with waterproof floors, and the brick walls that may partially surround the enclosure should be

water-proofed for a distance of at least 1 foot from the floor. The waterproofing commonly employed for the floors is asphalt or *asbestolin*, the latter being a composition that is placed directly on the finished floor and forms a permanent covering about $\frac{1}{4}$ inch in thickness, and of the nature of the best cork linoleum.

In waterproofing the walls, about the only practical method to employ is to give them several coats of an approved waterproof paint.

Fig. 6 illustrates a reasonably cheap and still excellent construction for toilet-room enclosures, the several details of the construction being sufficiently clear without further explanation.

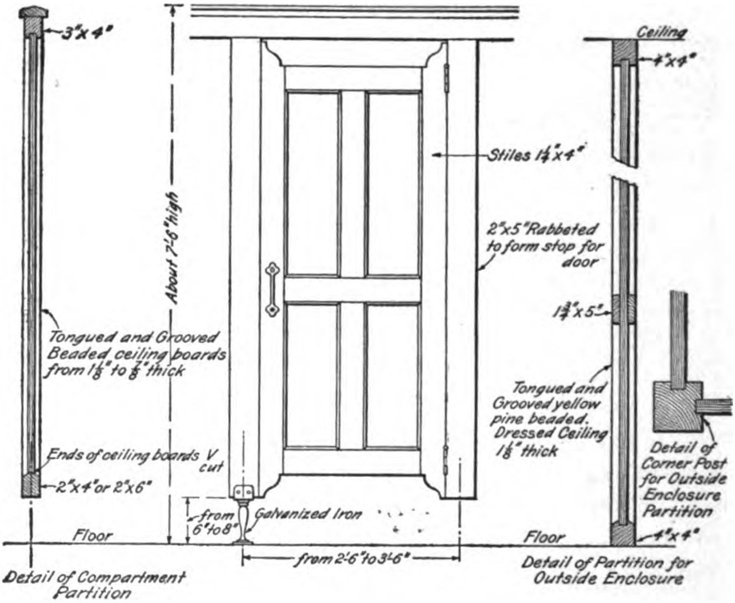
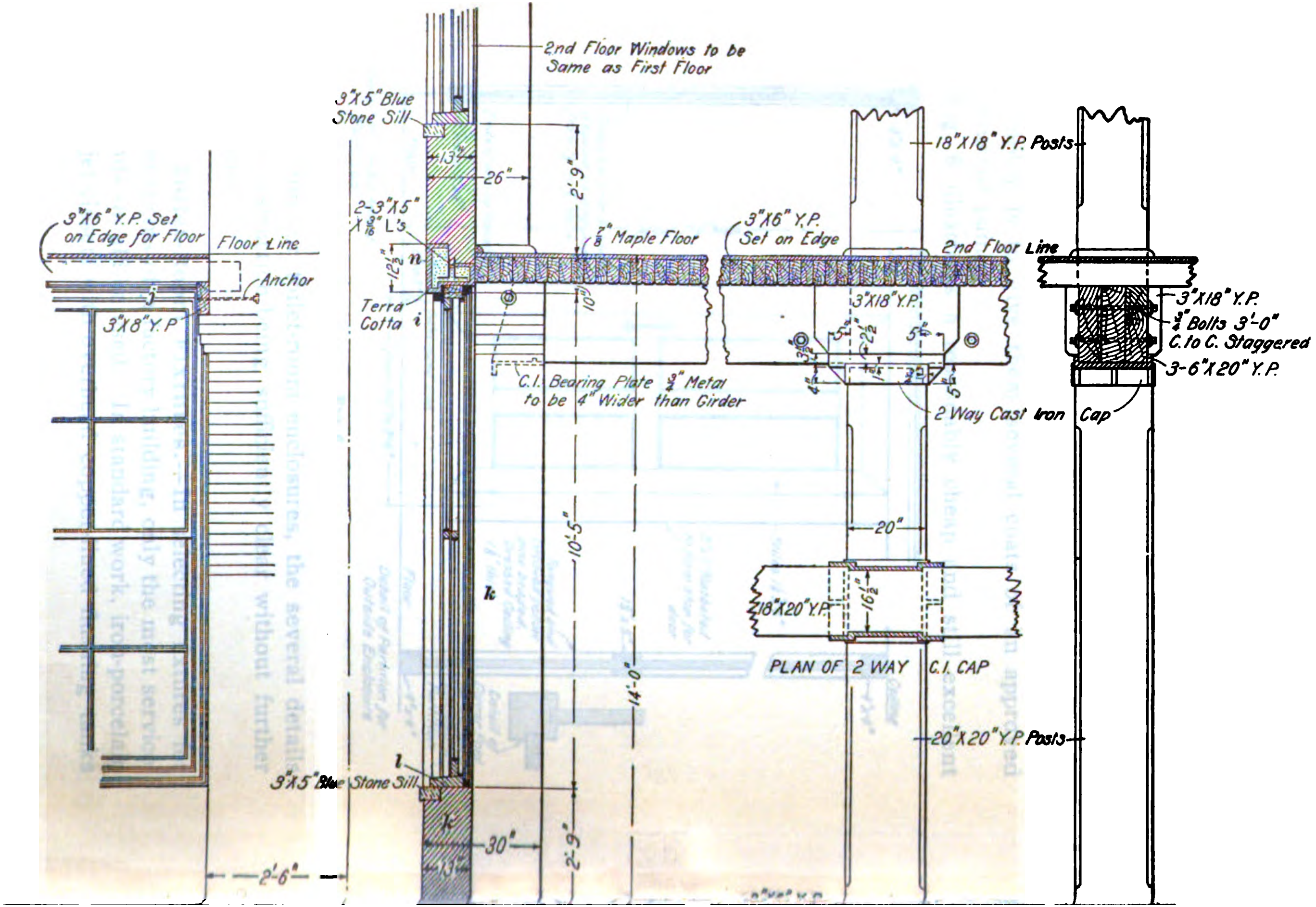

3"x4"
About 7'-6" high
Tongued and Grooved Beaded ceiling boards from 1⅛" to ⅞" thick
Ends of ceiling boards V cut
2"x4" or 2"x6"
Floor
Detail of Compartment Partition
from 6" to 8"
Galvanized Iron
from 2'-6" to 3'-6"
Stiles 1¾"x4"
2"x5" Rabbeted to form stop for door
Ceiling
4"x4"
1¾"x5"
Tongued and Grooved yellow pine beaded. Dressed Ceiling 1⅛" thick
Detail of Corner Post for Outside Enclosure Partition
Floor
4"x4"
Detail of Partition for Outside Enclosure

FIG. 6

19. Toilet-Room Fixtures.—In selecting fixtures for the toilet rooms of a factory building, only the most serviceable kinds should be used. In standard work, iron-porcelain siphon-jet closets with overhead copper-lined flushing tanks



2nd Floor Windows to be Same as First Floor
3"X5" Blue Stone Sill
13"
26"
2'-9"
3"X6" Y.P. Set on Edge for Floor
Floor Line
2-3"X5" X 3/16" L's
12½"
n
Anchor
3"X8" Y.P.
j
Terra Cotta
i
7/8" Maple Floor
10½"
C.I. Bearing Plate 3/4" Metal to be 4" Wider than Girder
10'-5"
14'-0"
k
l
9"X5" Blue Stone Sill
30"
13"
2'-9"
2'-6"
3"X6" Y.P. Set on Edge
18"X18" Y.P. Posts
2nd Floor Line
3"X18" Y.P.
5"
2½"
3½"
4"
2 Way Cast Iron Cap
20"
18"X20" Y.P.
16½"
PLAN OF 2 WAY C.I. CAP
20"X20" Y.P. Posts
3"X18" Y.P.
3/4" Bolts 3'-0" C. to C. Staggered
3-6"X20" Y.P.
Cap

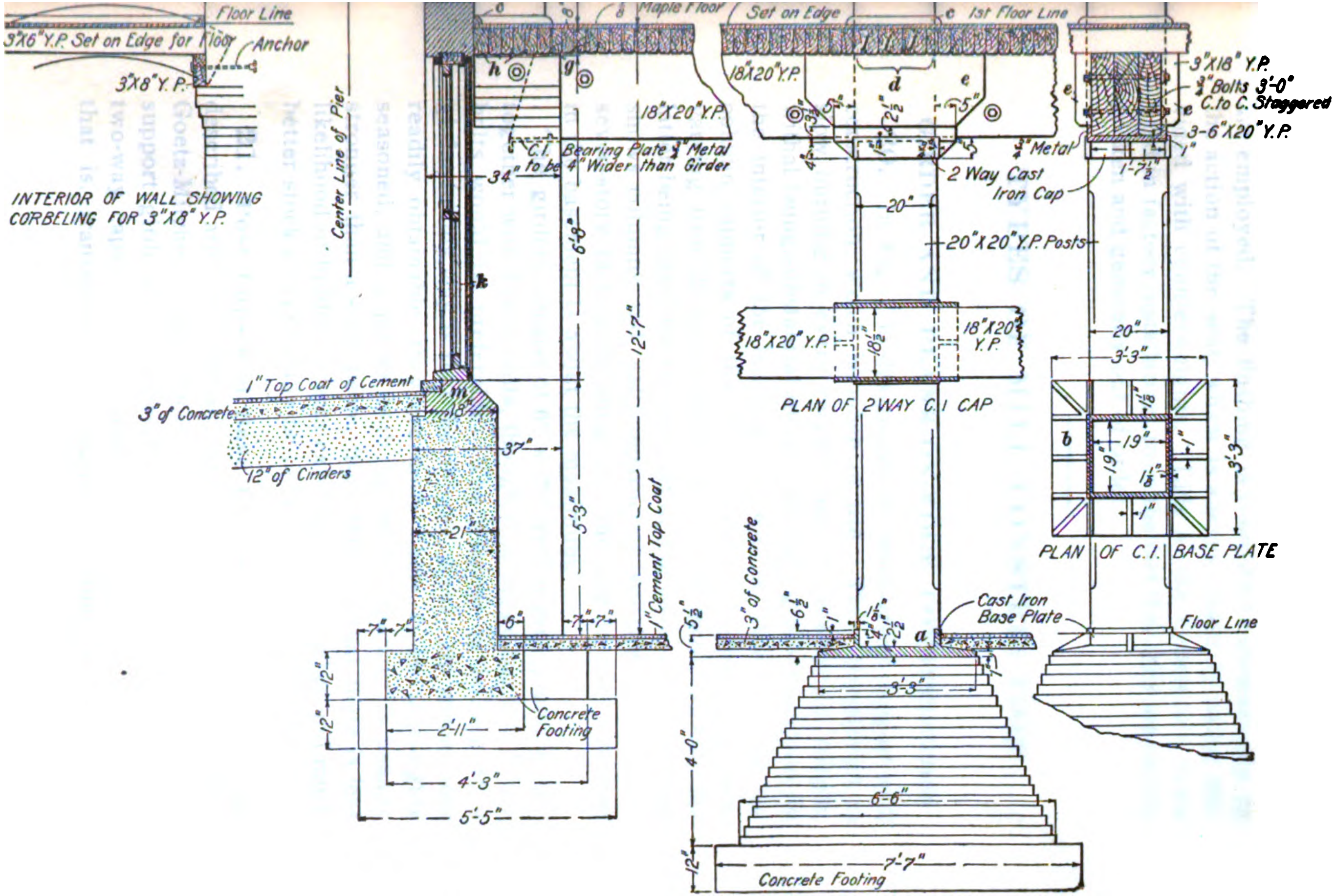

Floor Line
3"X6" Y.P. Set on Edge for Floor
Anchor
3"X8" Y.P.
INTERIOR OF WALL SHOWING CORBELING FOR 3"X8" Y.P.
Center Line of Pier
Maple Floor
Set on Edge
1st Floor Line
18"X20" Y.P.
h
g
k
m
a
b
c
d
e
34"
C.I. Bearing Plate ¼" Metal to be 4" Wider than Girder
¼" Metal
2 Way Cast Iron Cap
20"
20"X20" Y.P. Posts
3"X18" Y.P.
¾" Bolts 3'-0" C. to C. Staggered
3-6"X20" Y.P.
1'-7½"
6'-8"
12'-7"
5'-3"
37"
21"
18"
1" Top Coat of Cement
3" of Concrete
12" of Cinders
1" Cement Top Coat
18"X20" Y.P.
18½"
PLAN OF 2 WAY C.I. CAP
3'-3"
19"
1⅛"
1"
PLAN OF C.I. BASE PLATE
Cast Iron Base Plate
Floor Line
6½"
5½"
2½"
4'-0"
6'-6"
7'-7"
12"
Concrete Footing
2'-11"
4'-3"
5'-5"
7"
6"

FIG. 7

are employed. The flushing is controlled automatically by the action of the seat, which is always raised by being provided with counterweights. Lids to the closets are never used in factory installation, from the fact that they are readily broken and generally out of order.

TYPES OF MILL CONSTRUCTION

GIRDER AND PLANK-ON-EDGE CONSTRUCTION

20. In Fig. 7 is designated an economical type of mill construction, which is much in use. This construction is slow burning in every respect, and is exceedingly simple, withal being substantial and presenting a good appearance on the interior of the building. It will be observed that the column supports of the floor consist of yellow-pine posts, varying from 20 inches square to 8 or 10 inches square, the latter being used for the support of the roof. The drawing shows columns and wall construction suitable for a six- or seven-story factory building, and the size of post indicated in the basement is about the maximum.

The girders consist of 6″ × 20″ yellow-pine pieces bolted together with $\frac{3}{4}$-inch bolts, though it is suggested that $\frac{7}{8}$-inch bolts would be preferable. The purpose in bolting up a girder in this way is that the thinner planks are much more readily obtainable, they are more likely to be thoroughly seasoned, and a girder built up in this manner is usually stronger than a solid beam, from the fact that there is less likelihood of hidden defects existing in the timber and much better stock can generally be obtained.

21. Post Caps and Base Plates.—These girders just described are supported on cast-iron post caps, similar to the Goetz-Mitchell construction. These post caps, where they support girders in one direction only, are usually known as two-way caps. If they support girders in two directions—that is, transverse and longitudinal—they are known as four-way caps. These caps are generally cast of $\frac{3}{4}$-inch metal, and the girders bear on them at least 4 inches.

For the basement columns, it is usual to provide a cast-iron base plate, as indicated at *a*. The timber column is sized into the socket of the base plate, and it is best to carry the top edge of the cap well above the floor, so that any moisture from leakage or in washing the floor will not be allowed to penetrate to the wood. Owing to the fact that this base plate must transmit the entire load on the column to the brick, it must be heavily webbed on the sides and corners, as indicated in the plan at *b*.

22. Concrete Footings.—It is usual in designing the foundations for mill buildings to use concrete footings, as indicated in the plan. It will be noticed in this particular instance, and it is the usual practice, that the concrete footings are 12 inches in thickness. When the footings are stepped, as indicated, under the wall of the building, each footing is made about 12 inches in thickness, with a projection of not more than 6 or 7 inches.

23. Floor Construction.—The floor construction of the building consists of 3″ × 6″ yellow-pine pieces, set on edge and spiked together. Such a construction as this is available for spans between girders of from 10 to 15 feet, and does away with all secondary girders, or beams. It also has an advantage in that it presents a neat ceiling beneath when the edges of the planks forming the rough flooring are beveled. On the top of this rough flooring, which is designed for carrying the floor load, and which is so constructed that the joints in the different pieces are broken, a 1-inch or $1\frac{1}{4}$-inch maple flooring is laid. Maple is used for finished floors in factories principally on account of its hardness and the excellent wearing surface that it affords. The maple flooring available in the market runs in lengths of from 3 to

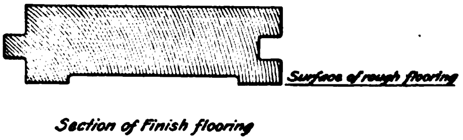


FIG. 8

16 feet, but the cost of the floor is greatly increased if a minimum length of 6 or 8 feet is specified. Usually the flooring is tongued and grooved and hollowed on the back, as indicated in Fig. 8. The hollow back prevents the flooring from curling. In a better class of finished flooring, the pieces are end-joined, or provided with a tongue and groove on the end. This prevents the end of the flooring from turning up and interfering with the smoothness of the floor and the operation of trucks over it.

24. **Waterproofing and Dust Proofing.**—For the purpose of deadening sound, and sometimes for the sake of waterproofing, sheathing paper or felt is inserted between the finished flooring and the rough plank. By the introduction of paper between the maple and the rough flooring, dust and dirt are prevented from falling through the crevices due to the shrinkage of the flooring boards above.

It is usual in finishing a floor around the edge to use about 2-inch quarter-round molding, as indicated at *c*, Fig. 7. This molding is also used around the wooden columns, or posts.

In order to prevent the posts from splintering at the corner, and so that there is less likelihood of the occupants being hurt, a stop-chamfer, or arris, is formed on the corner.

25. **Splice Pieces.**—There is one feature which must not be overlooked in mill construction, such as occurs in this figure, and that is that since the girders butt against the columns on top of the post caps, usually flush, there is nothing to carry the boards at *d*, therefore yellow-pine pieces or steel angles must be provided, as indicated at *e*. These splice pieces answer two purposes, namely, to form a bearing for the ends of the planks *f*, *f*, *f*, and also to tie the girders rigidly together longitudinally, and thus increase the rigidity of the floor construction.

For a similar reason, it is necessary to form a ledge, either by reducing the size of the pier above, or by corbeling out, at the window openings, as shown at *g*, for the support of the floor planks at *h*, *h*. On the top of the corbel so formed, usually a 3″ × 8″ yellow-pine piece is securely anchored to the wall, to provide a bearing for the ends of the rough floor planking.

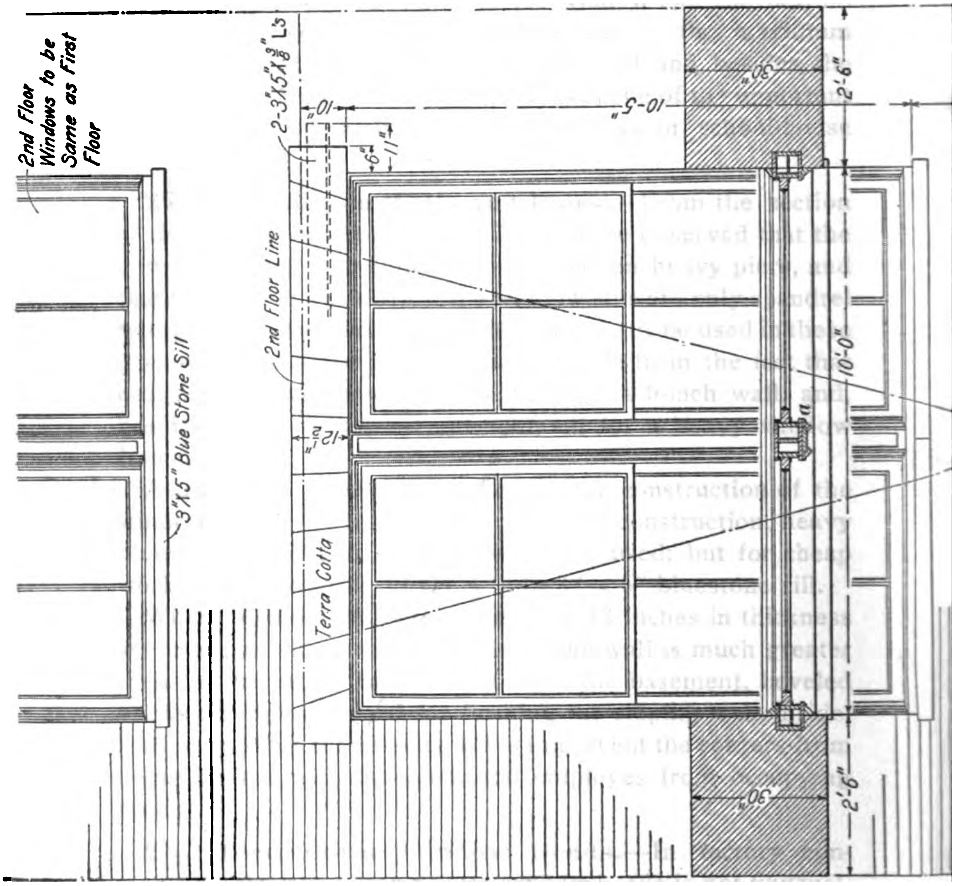
26. Reference to *i* and *j*, Fig. 7, shows that there is very little room between the head of the window and the bottom of the floor construction. By this means, the maximum amount of light near the ceiling is obtained, and, besides, the ventilation is greatly facilitated. This is one of the important features in factory designing, as well as in school-house architecture.

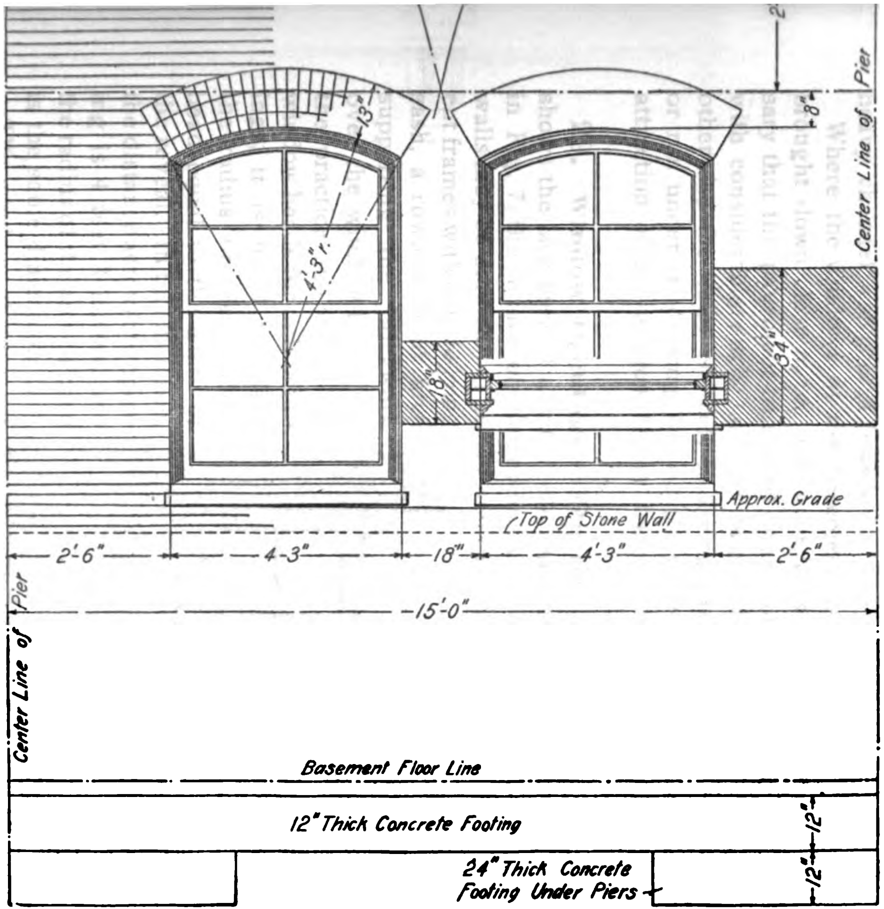
27. Foundation Walls and Piers.—From the section of the wall shown at *k*, *k*, Fig. 7, it will be observed that the entire building is practically supported on heavy piers, and that the 13-inch walls below the window sills are only spandrel fillings. In some instances, 9-inch walls can be used in these places, but it is not considered advisable from the fact that beating rain will readily drive through a 9-inch wall, and, besides, there is hardly sufficient sill for a heavy window frame.

Attention is particularly called to the construction of the window sill at *l*. In the better class of construction, heavy bluestone sills 5½ in. × 7½ in. would be used; but for cheap work, it is customary to use a light 3″ × 5″ bluestone sill.

Where spandrel fillings more than 13 inches in thickness are used, or where the thickness of the wall is much greater than the frame, as indicated at *m* in the basement, beveled bricks on edge are used for forming the sloping wall inside. The purpose of the sloping sill is to prevent the corners from being broken and damaged, and employes from occupying them.

28. Terra-Cotta Window Heads.—In factory construction, the use of terra-cotta window heads is not unusual, and the construction of such a window head is indicated at *n*, Fig. 7. Where terra-cotta window heads are used in this manner, some means of support must be had for the brickwork above the window head, as terra cotta in itself is of little use as an arch, or lintel. It is not uncommon to use


2nd Floor Windows to be Same as First Floor
3"X5" Blue Stone Sill
2-3"X5"X3/8" L's
10"
6"
11"
2nd Floor Line
12½"
Terra Cotta
10'-5"
30"
2'-6"
10'-0"
a
30"
2'-6"



ELEVATION

FIG. 9

angle irons back to back, as indicated on the section of window head *n*. This construction, of course, can only be used where the wall runs parallel with the supporting floor, for if the head of the window receives beams or girders it must necessarily be more strongly and rigidly constructed with heavy channel irons, or I beams.

Where the windows of the basement, as shown at *m*, are brought down close to the pavement, it is absolutely necessary that the pavement be sloped away from these windows with considerable pitch, not less than 1 inch in 1 foot, as otherwise the water is likely to lay against the window sill or run under it, causing it to rapidly decay, the capillary attraction of the window frame drawing up the water.

29. Window Openings.—Referring to Fig. 9, which shows the face view of a bay of the wall illustrated in section in Fig. 7, the details of the several window openings in the walls may be studied. The basement windows are independent frames with double-hung sash, a rowlock brick arch supporting the brickwork over the window head. In the practice and design of window heads for mill buildings, it is usual to make the radius of the window head equal to the width of the reveal. In this instance, the distance across the opening is 4 feet 3 inches, and the radius of the arched head is the same dimension.

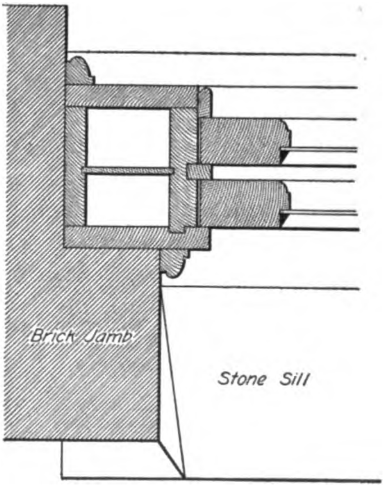


FIG. 10

The windows throughout the balance of the building are twin windows, double hung, and the construction of the window frame and sash is shown in the drawing. This frame is what is known as a **reveal frame**, and is built in as the brickwork progresses.

Sometimes the frame is slipped in from the back, as shown in Fig. 10, and when this is the case the work can be carried along without waiting for the window frames.

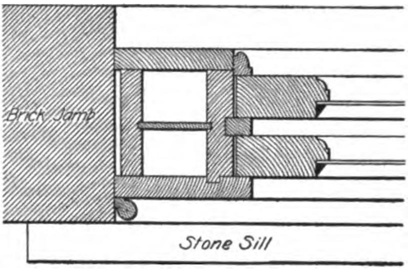


FIG. 11

As distinguishable from the reveal frame, there is the **plank-frame construction,** which is not built into the brickwork, but is built up as shown in Fig. 11. When it is desirable to have the central mullion *a*, Fig. 9, as narrow as possible, the box construction indicated on the drawing is done away with and the window is hung by means of overhead pulleys, the weights operating in the boxes at the sides.

STANDARD SLOW-BURNING CONSTRUCTION

30. A type of factory construction more usual than that previously described is illustrated in Fig. 12. In this illustration, it will be noticed that the main girders bear on wall pilasters, and the spandrel filling between the pilasters is kept as thin as possible. The usual reveal window frame is used, as shown at *a*, and the soffit of the arch over the window openings is checked at the head of the opening to provide a wind and water stop as at *b*. In this construction, which is probably the best, though it does not possess the advantage of giving the maximum amount of window space, and, consequently, light in the building, a rowlock or bonded brick arch is used over the window frames. By means of this construction, either the window frame may be built in place, or the windows may be slipped in from the back against a rabbet formed in the brickwork. The arch over the window head is indicated at *c*.

31. Floor Construction.—The floor construction consists of heavy timber girders, no dimension of which may be less than 6 inches, as otherwise it would not comply with the requirements of slow-burning construction. The floor planking consists of 3- or 4-inch tongued-and-grooved spruce, or yellow-pine planking, planned on the under side, and thoroughly spiked to the girder. Planking of the former thickness may be used for clear spans as great as 8 feet,

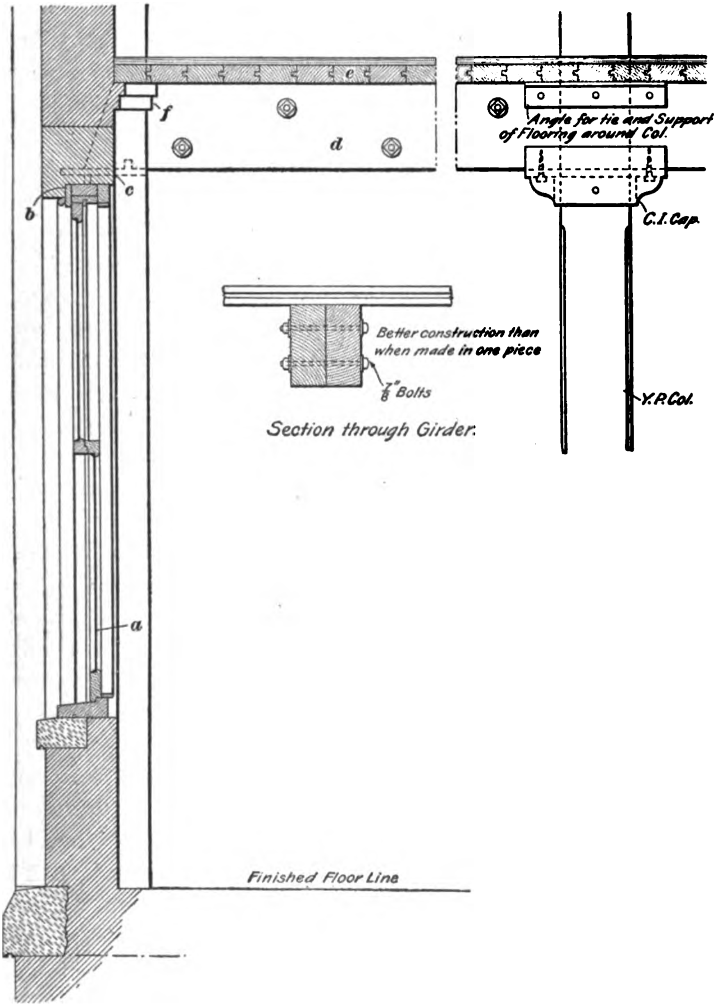

e
f
d
c
b
a
Angle for tie and Support of Flooring around Col.
C.I. Cap
Better construction than when made in one piece
$\frac{7}{8}$" Bolts
Section through Girder.
Y.P. Col.
Finished Floor Line

FIG. 12

while the latter thickness may be used for up to 10-foot or even 12-foot spans, if the loads are light. The girders are indicated at *d*, and the floor planking at *e*. Usually the girders, in order to obtain the requisite strength, are made of long-leaf yellow pine. On the top of the spruce planking is placed a finished maple floor. This floor is made from either 1-inch maple, which finishes as $\frac{7}{8}$ inch, or $1\frac{1}{4}$-inch maple, which finishes as $1\frac{1}{8}$ inches, in thickness. Neponsett sheathing paper, or deadening felt, is placed between the spruce planking and the finished maple flooring for the purpose of preventing dust from percolating through. This sheathing paper or felt is sometimes made waterproof to prevent leakage due to water used for fire-extinguishing purposes.

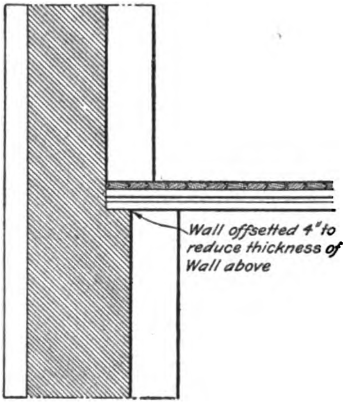


FIG. 13

Frequently, the brickwork is corbeled out, as indicated at *f*, in order to form a fire-stop between floors, or at least to prevent an open joint at this place. Where the walls are offsetted, as shown in Fig. 13, there is no need of corbeling out, for the offset in the brickwork can be made to form the fire or dust stop.

32. Where heavy yellow-pine girders bear on brick walls, it is usual to obtain the requisite bearing area by the use of cast-iron bearing plates, as indicated in Fig. 14 (*a*), (*b*), and (*c*). In (*a*) is shown an ordinary flat plate that has an area figured so that the load on the brickwork will not exceed its ultimate stress, which for brickwork laid in lime-and-cement mortar is about 150 pounds per square inch, while for brickwork laid in cement mortar, it is in the neighborhood of 200 pounds per square inch. This plate is usually cast with a lug on the back, as at *a*, to be built in the brickwork, and dowel-pins, or a lip, as at *b*, over which the girder is fitted, or notched. By this means, a tie to the wall is obtained. There is difficulty, however, in using such a connection, for the carpenters on the job frequently miscut their beams, so that the notchings or borings at *b* do not come where they should, and to remedy the defect, the notchings, or borings, are cut or gouged out, so that frequently the pin or lip at *b* is not brought to bear against the timber.

A more practicable bearing plate is illustrated in Fig. 14 (*b*). Here, instead of providing dowels, or a lip, to set into the girder, the top of the plate is cast with teeth, as indicated at *c*. While these teeth tend to destroy fibers at the bottom of the beam, they nevertheless sink into the timber, creating great friction, and thus accomplish a tie to the wall fully as efficient as a dowel-pin, or lip, let into the timber would be.

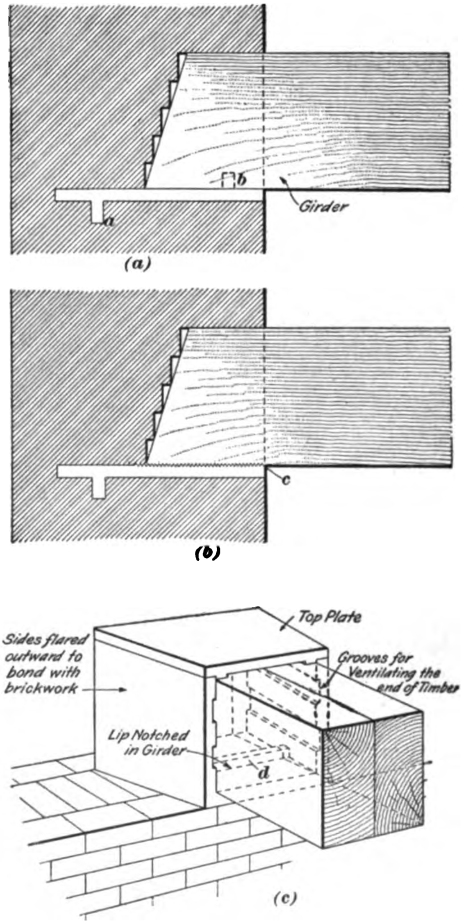

b
a
Girder
(a)
c
(b)
Top Plate
Sides flared outward to bond with brickwork
Grooves for Ventilating the end of Timber
Lip Notched in Girder
d
(c)

FIG. 14

Probably the most common form of bearing plate is that illustrated in Fig. 14 (*c*), which is known as the Goetz-Mitchell bearing box. This is usually built flared, as indicated in the illustration, so that when built into the brickwork it will have a hold in it, and the timber acts as a tie by being notched over the lip, as at *d* in this figure. These Goetz-Mitchell boxes are generally provided with a plate that sets on top of them, on which the brickwork may be built, and not infrequently the sides of the boxes are grooved so that the ends of the girders are ventilated.

33. Window Heads.—In Fig. 12 was shown a form of window head that is the best for strength, but possesses the disadvantage of lowering the top of the window, thus cutting off light to the room, which is a serious objection where the room is wide, or where it depends on the windows in one side for lighting the entire floor area. In order to keep the window head up near the under side of the floor construction, an I beam, lintel, or some similar form of support for the brickwork over the head that takes up little room, must be employed. A construction using shallow I beams is illustrated in Fig. 15. Here the window head is directly beneath the rough flooring; and while the outside face of the window is formed with an arch, the brickwork above the window head is supported on shallow I beams. This figure illustrates a section through the wall extending parallel with the main girders, a bearing being obtained for the floor planking by bolting to the I beams a bearing strap *a*.

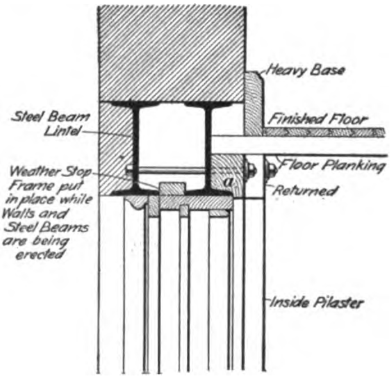


FIG. 15

This construction would not be permitted in some of the larger cities, as the building laws require that all steel beams supporting brickwork must be fire-proofed. Consequently, a steel lintel of this construction would have to be surrounded with concrete, and the window head dropped somewhat to allow a bearing for the floor planking, or some other form of construction adopted.

FACTORY BUILDINGS OF REINFORCED CONCRETE

34. Within the last few years, the cost of the best Portland cement has been so materially reduced that concrete has become an available material for the construction of factories. Unless used in great masses, however, it has not the strength to support the necessary floor loads without the use of steel reinforcement. As explained in *Design of Beams*, the

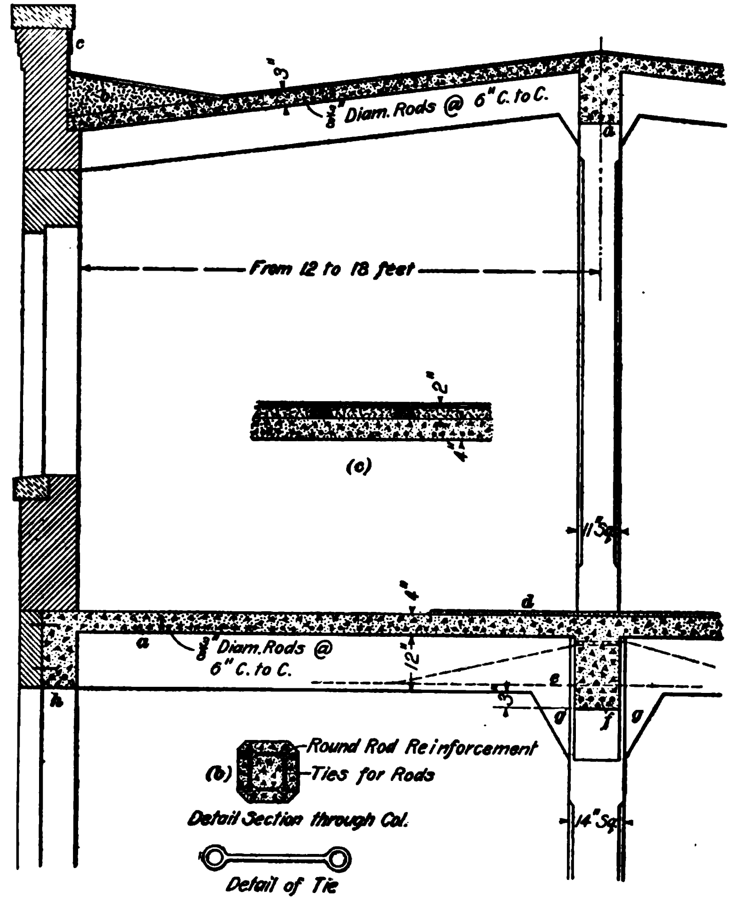


FIG. 16

fibers on the bottom of all beams subjected to transverse stress are in tension, and while concrete has considerable resistance to compression, it offers comparatively little to tensile stress. It is therefore necessary to reinforce the lower portion of all beams and floor slabs as indicated at *a*, Fig. 16.

35. Advantages of Reinforced Concrete.—In Fig. 16, the details of a typical reinforced-concrete factory building are illustrated, and a building of this character may be constructed for a cost of from 10 to 15 per cent. greater than the ordinary slow-burning type of building. Besides, this construction possesses the advantage of being practicable for long spans and heavy loads, whereas in buildings of the slow-burning type, owing to the fact that the size of the wooden beams is limited to the available commercial timber, it is frequently impossible to design floors with girders of large spans for floor loads of over 250 pounds per square foot. While this is a heavy load, it is too light for some classes of work, such as occur in printing houses and lithographing establishments where heavy stones are used and stored. The floor loads in such buildings sometimes amount to as much as 300 or 400 pounds per square foot, while it is not unusual to find the load on floors in warehouses amounting to as much as 500 pounds per square foot.

36. Strength of Concrete Columns With Steel Cores.—In the building shown in Fig. 17, it will be noticed that the columns are reduced in size in the lower floors, increased in the middle portion of the building, and reduced toward the roof. The reduction in the columns *a* and *b* is due to the fact that these columns are reinforced with a steel core composed of structural shapes riveted together, angles usually being employed for this purpose. In proportioning such columns, it is good practice to figure on the ultimate safe unit compressive stress of the steel without considering the reduction made by the usual column formula, but to neglect, in the consideration of the strength of the column, the resistance of the concrete surrounding the steel core.

To illustrate, if the sectional area of the steel reinforcements in these columns equals 20 square inches, and a safe unit fiber stress of 16,000 pounds is assumed, the safe strength of the column will be 320,000 pounds.

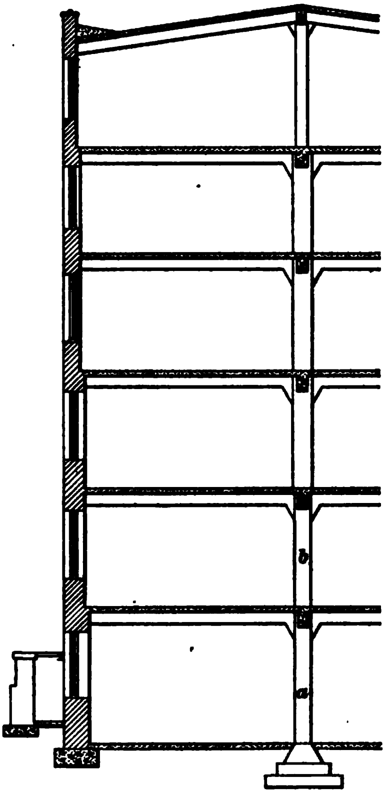


FIG. 17

Above the second floor, the columns are made much larger, for here there is less steel reinforcement, and it is necessary to figure on the safe bearing strength of the concrete.

37. Strength of Reinforced-Concrete Columns. In proportioning reinforced-concrete columns, it is customary among conservative engineers to figure the safe strength of the concrete-column section at 500 pounds per square inch of section; that is, if the column is 20 inches square, its area is 400 square inches, and its safe strength at 500 pounds per square inch will be 200,000 pounds. In the top floor, it is seldom advisable to use concrete columns less than 10 inches square, though at this dimension they generally possess several times the requisite amount of resistance.

All columns in reinforced construction generally have embedded in them $\frac{3}{4}$-inch to 1-inch round steel rods, tied together with round iron binders, or bar-iron straps as indicated in Fig. 16 (*b*).

38. Floor and Roof Construction.—In considering the floor and roof construction of buildings built of reinforced concrete, it will be noted from Fig. 16 that the roof slab is made 3 inches in thickness. Such a slab made of good concrete, reinforced with $\frac{3}{8}$-inch steel rods, spaced 6 inches from center to center, will carry the usual roof loads for spans up to 7 feet in the clear.

In forming the gutter for such roofs, as indicated at *b*, the gusset is made by filling in with cinder concrete. Usually cast-iron eave boxes are embedded in the concrete, and these in turn connected with inside rain conductors.

The beams supporting the roof, when the span is from 12 to 14 feet, are made about 12 inches deep and 8 inches wide, while the girders, also constructed of reinforced concrete, are usually made about 3 inches deeper and 11 inches in width.

In order to make the roof impervious to moisture, a covering of felt and slag is commonly employed. This slag joins the parapet wall with the usual tin flashing and counter flashing, as at *c*, though copper is recommended for best work.

In the floor construction of reinforced-concrete factory buildings, the slabs forming the floor panels are made not less than 4 inches in thickness, and seldom over 5 inches, with a 1-inch finish coat of cement besides, if this character of finish is desired. Such a floor slab is shown in the construction at *d*, Fig. 16, while the wooden floor construction is shown in Fig. 16 (*c*). Here the structural feature of the floor is a 4-inch concrete slab upon the top of which is placed 2″ × 3″ beveled hemlock sleepers, the space between these sleepers being filled with cinder concrete, and the floor finish obtained by laying 1-inch tongued-and-grooved maple floorings.

39. Reinforced-Concrete Beams and Girders.—The depth of the beams and girders in reinforced-concrete construction varies, of course, with the span and loads to be supported. Their width enters little into the strength, and they may be made as narrow as possible in order to cover the reinforcing steel. It is the best practice to make beams and girders of the same width, for then the process of forming the molds is greatly simplified and the cost reduced.

In placing the reinforcement in the concrete, it should always be at least 2 inches from the outside surface, for a distance less than this is considered inadequate fireproofing. In order that the reinforcing metal *e*, Fig. 16, may enter over the top of the reinforcing metal at *f*, it is usual to make the secondary girders, or beams, 3 inches less in depth than the main girders. To stiffen the building, brackets are customarily introduced between the column and girders, as illustrated at *g*. These brackets tend to greatly increase the rigidity of the connection and shorten the span of the girder somewhat.

40. Construction at Window Heads.—Where it is necessary to have the window head near the top of the ceiling, reinforced-concrete construction lends itself readily to the requirements of this condition, for even where girders are supported over the window head, the construction may be followed out, as indicated at *h*, Fig. 16. Where it is desired to have the window head raised still higher, a construction similar to that shown in Fig. 18 may be used. In this case, however, care must be taken to have the girders bear on the piers between the windows, and to have no intermediate beams.

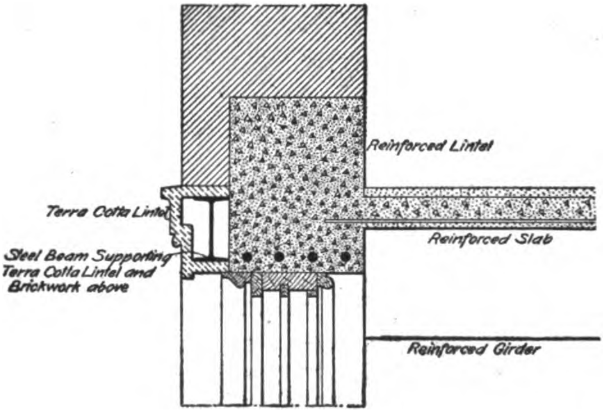
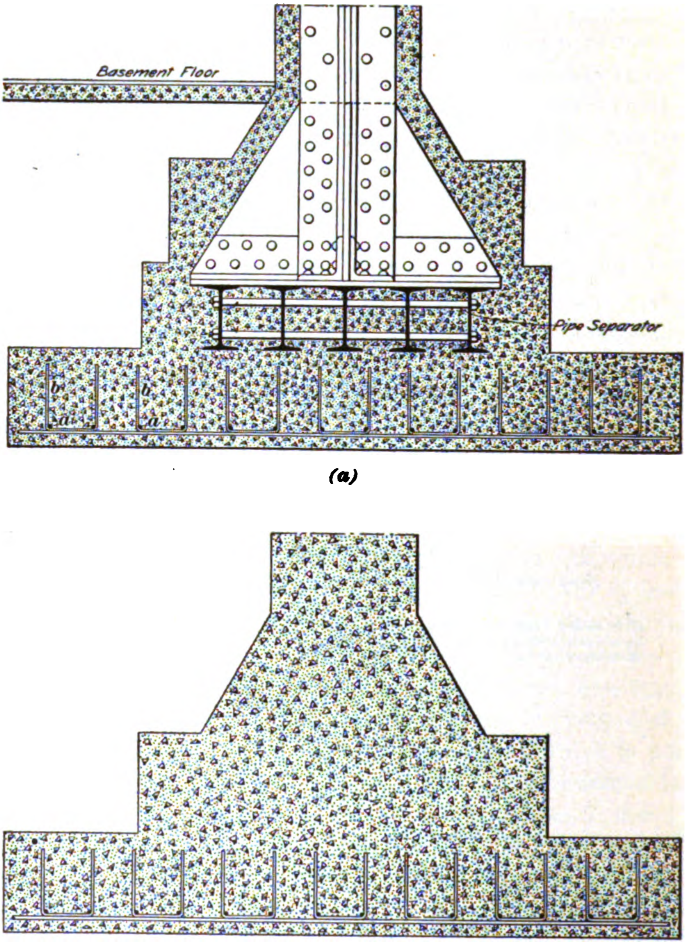


FIG. 18

41. Column Footings.—With factory buildings of more than five or six stories in height, great pressure is transmitted to the soil from the base of the bottom column, and as it is necessary with soils of even fairly good bearing capacity to have footings beneath the piers supporting columns of from 6 to 10 feet square, adequate means of providing these



(a)

(b)

FIG. 19

footings must be obtained. In Fig. 19 (*a*) and (*b*) are shown two types of footings for concrete columns. In (*a*) is indicated a reinforced-concrete column with a steel core. In such an instance, all the load is transmitted by the steel core through its angle plates and webbing at the foot to grillage beams. These grillage beams are, however, not made sufficiently large to transmit the load to the soil, but merely to distribute the load on the bed of concrete. The spread portion of the footing is reinforced with steel rods *a*, *a* crossed each way, and longitudinal shear is taken up in the footing by means of stirrups *b*, *b*. This is the usual type of footing construction under reinforced-concrete factory columns.

Where, however, the column is not reinforced with a steel core, but is merely a pier, footings may be designed as illustrated in Fig. 19 (*b*). Here the base of the column is enlarged in order to better distribute the load on the several steps of the footing, and where the bottom step has a considerable overhang, it is reinforced with steel rods and stirrups, as indicated.

42. Detail of Slab and Girder Reinforcement.—In the previous article, the general construction of the floors and column supports of a factory building was explained. By referring to Fig. 20, it will be shown how the girders and beams are reinforced with the steel bars. In this figure, a plan is indicated at (*a*) and an elevation at (*b*). The rod reinforcement of the slab is shown in the plan at *a*, *a*. It will be noticed that over every other beam these rod reinforcements lap, or break joints, and that some additional tie or reinforcement is placed over the girders, as indicated by *b*, *b*. These latter rods tend to tie in the floor slabs still more rigidly than can be accomplished with their individual reinforcement.

Referring to the elevation (*b*), it will be noticed that all the reinforcement of the beams is not usually carried along the lower portion of the girder for its entire distance, but that some of the reinforcement is bent up at a point about one-quarter of the span from the abutment, in the form of a camber rod. By arranging the reinforcing rods in this manner, an additional stirrup action, or tie, to the girder supports is provided, and the oblique section made by a horizontal line passing through these rods tends to provide additional resistance to the horizontal shear in the beams and also provide for negative bending moment produced in the beams near the support. To further provide for this, shear stirrups are placed closer together, toward the abutments, as indicated at *c*, *c*. These stirrups are ordinarily light pieces of bar iron bent in a **U**-shape, and sometimes bent around the rod reinforcement, a detail of this stirrup being shown in Fig. 20 (*c*).

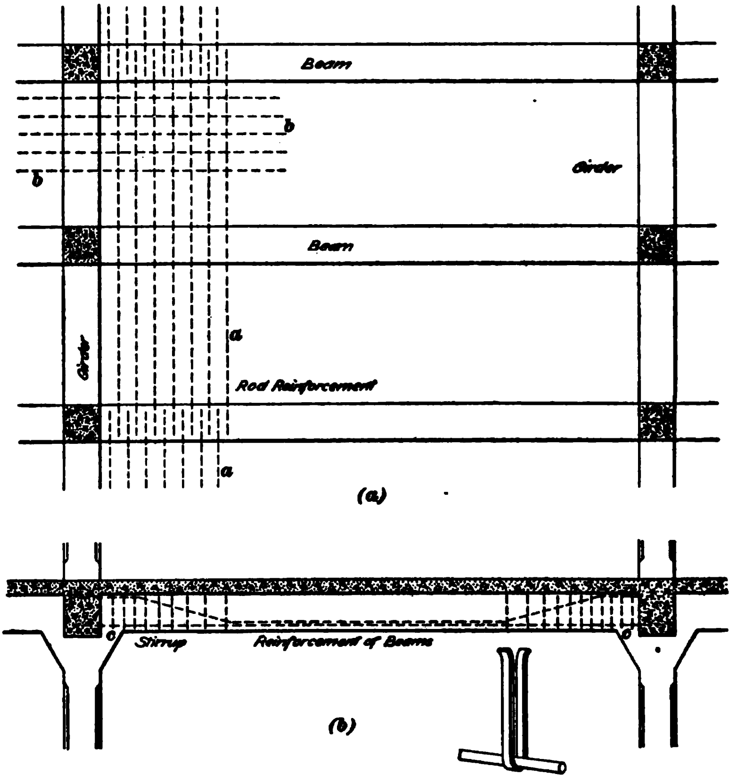


Fig. 20

STEEL-FRAME MILL BUILDINGS

43. There is a type of building which, while not distinctly mill construction as usually understood, is frequently used for one-story buildings, such as rolling mills, cement works, machine shops, foundries, rail yards, and buildings of this class.

The essential feature of these buildings is a steel-roof truss supported on steel columns, the columns being braced both to the truss and longitudinally of the building. It is usually the purpose in the design of such buildings to neglect everything but the necessary stability and the first cost. The steelwork, consequently, is of the lightest possible construction, usually designed for a unit fiber stress of from 18,000 to 20,000 pounds, and the covering of the sides of the building, together with window details, etc., is made only sufficiently good to keep out the weather.

44. Material for Roof Covering.—The roof covering of this class of building is either of slag on 2-inch spruce plank, spiked to nailing strips bolted on to steel purlins from beneath, with lagscrews, or of slate laid on 1-inch or 2-inch sheathing boards. Even galvanized iron is used for the roofing of some of the cheapest class of buildings, especially those which, owing to the process of manufacture, are subjected to a high temperature.

45. Construction of Sides of Building.—The sides of these buildings may be covered with either expanded-metal lath on metallic furring strips, plastered inside and out with cement mortar so as to form a fireproof and rigid screen wall about 2 inches in thickness; or, the walls may be 9-inch or 13-inch brick walls built part way up the height of the columns and leaving the columns exposed on the face; or, corrugated galvanized iron lapped 6 inches and secured either by riveting to metallic supports or nailed to wooden studding secured to the steel frames. Of these constructions, probably the first is the most expensive and also the most satisfactory.

46. Partially Supported Steel-Frame Building. In Fig. 21, there is designated a type of construction that may be built for about $1 per square foot of the area covered. This consists of steel I beams, or angle-and-plate columns, used for column supports carrying the usual angle iron

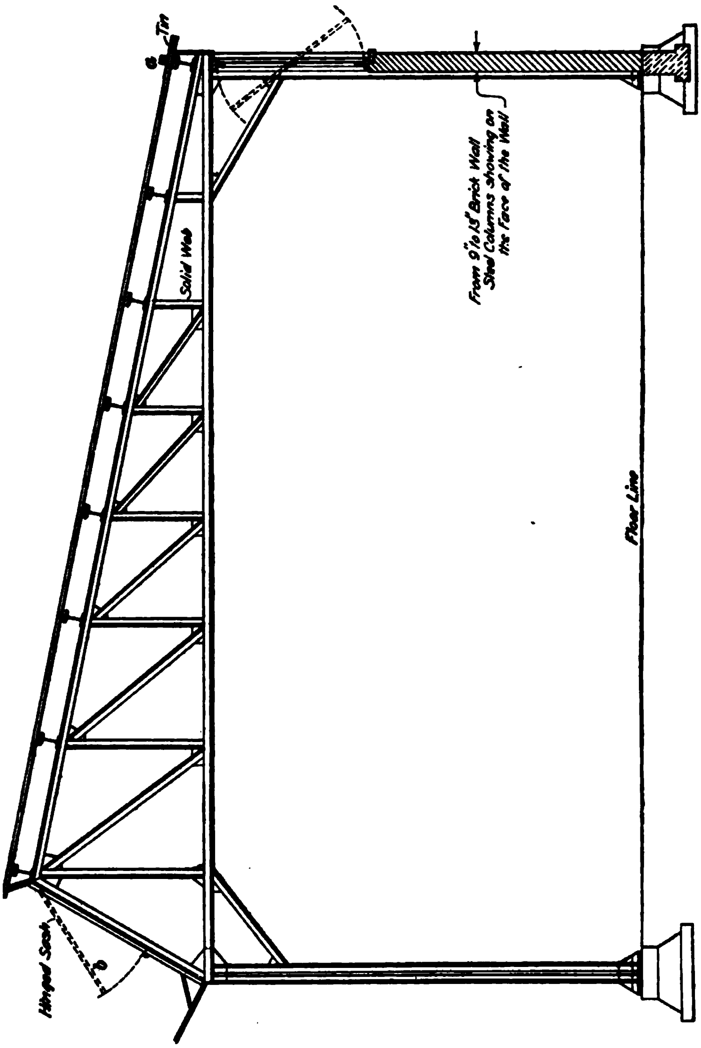

Tin
Solid Web
From 9" to 15" Brick Wall Steel Columns showing on the Face of the Wall
Floor Line
Hinged Sash

FIG. 21

steel-roof truss. The roof is sheathed with 2-inch spruce tongued-and-grooved planking, covered with a good quality of roofing felt and slag, with a stop-gutter *a* at the edge. Owing to the fact that the steel columns are supported in a direction of their minimum radius of gyration by means of the brick walls, they can be made very light. The building illustrated has what is known as a *saw-tooth roof*. By this means, light is obtained on the side next to an adjacent and higher building by means of a sash *b*. This sash is usually made hinged or pivoted, to provide the necessary ventilation.

47. In Fig. 22, there is illustrated, diagrammatically, the framework of a one-story skeleton-construction building.

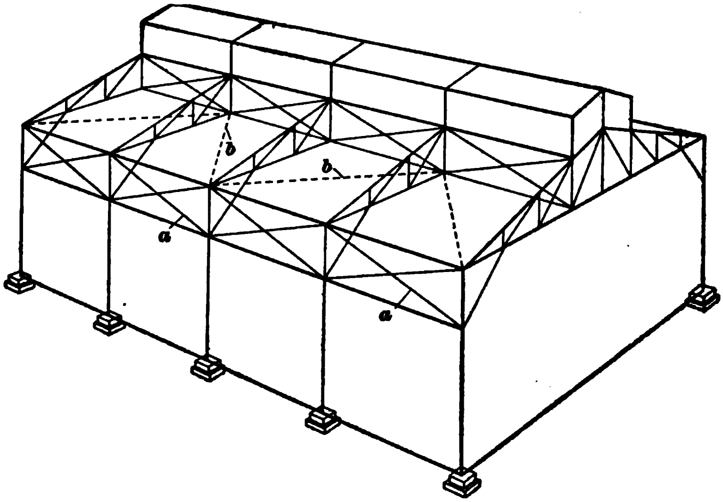


FIG. 22

In the design of all such buildings, where there are no end gable walls, the several columns and trusses must be braced diagonally, as indicated at *a*, *a*, and frequently it is necessary to introduce a secondary system of horizontal bracing from one panel point on the lower chord to another, as indicated at *b*, *b*.

In placing galvanized ironwork on the sides of steel-mill buildings, it is best to construct the necessary framework between the main supporting members of the building of light angles, or tees. These should be furnished punched with $\frac{3}{8}$-inch or $\frac{5}{16}$-inch holes, to which the galvanized iron may be riveted, it being best to mark the galvanized iron in the field and punch it there. This may be done without much difficulty with the usual light gauge used for this purpose. It is sometimes necessary with this construction to flash around the window and door heads with IX tin.

DETAILS OF MILL CONSTRUCTION AND DESIGN

STRUCTURAL FEATURES

BEAM CONNECTION TO GIRDERS

48. In factory construction, the headroom is seldom available to support beams on the girders, as indicated in Fig. 23 (*a*). It is usually necessary, in order to cheapen the construction of mill buildings, to keep the distance between the clear headroom and the finished floor level to the very minimum, and consequently the tops of the beams are most always brought flush, or nearly so, with the top of the girder.

A common construction is to use some of the various forms of wrought-iron hangers, as shown in Fig. 23 (*b*). The type of hanger shown is a single stirrup, and is probably the best of any on the market; where beams enter the girder on both sides, the hanger is designed double. While it is popularly supposed that this hanger would readily fail by the bending of the metal at *a*, it is usually proportioned to safely carry any reaction imposed under ordinary floor loads. This hanger is obtained stamped out of steel plate or formed from bar iron.

49. Where it is not desirable to use wrought-iron or steel hangers, a simple and inexpensive form of construction may be adopted as that shown in Fig. 23 (*c*). Here the beam *a* is supported on a wooden strip *b*, which extends the full length of the girder, and is bolted near the bottom with through bolts. Such a construction provides sufficient strength for the support of the average factory floor, but its strength is difficult to figure with any degree of certainty, and some surer form of connection is generally considered preferable. In all instances, it is good practice to tie together the opposite floor-beams butting on a girder by means of an iron dog, or tie-plate, *c*.

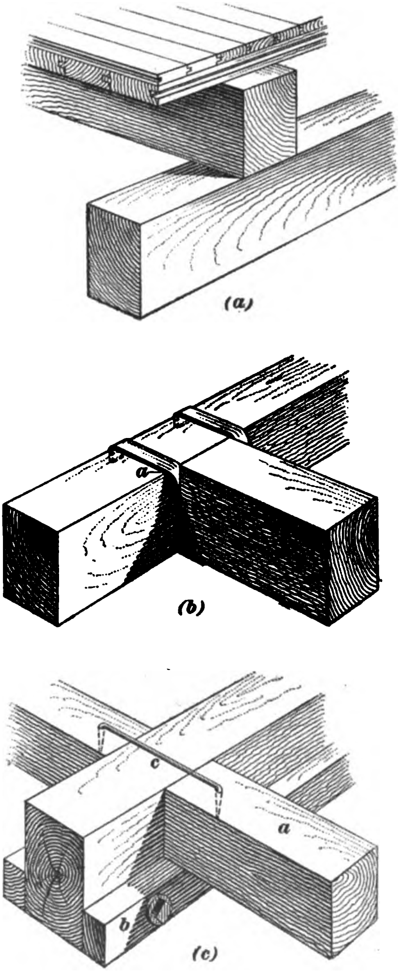


FIG. 23

50. In Fig. 24 (*a*), (*b*), (*c*), and (*d*) are indicated other methods of supporting the secondary floor-beams on main girders in the construction of factories. In Fig. 24 (*a*) is shown an I-beam girder supporting heavy timbers of a floor of slow-burning construction. It is always necessary in this construction to bring the top edge of the timbers above the upper flange of the I beam, and to span the space *a* thus created with a piece of timber for a tie and for the support of the floor planking. By providing this space between the ironwork and the wooden tie, any shrinkage that may occur in the secondary timbers will not cause the floor to ride on the top of the steel beam and thus make a ridge evident in the finished floor at this place. The timbers forming the secondary girders may either be supported on angle-iron brackets, or on angle irons extending the entire length of the girder. The latter method is only pursued when it is necessary to keep the end of the timber a few inches away from the steel beam, and the angle, consequently, being subjected to a greater bending moment, must have more resistance by increasing the width of the section of the bracket.

Sometimes, the secondary beams are supported on double stirrup hangers, as shown in Fig. 24 (*b*). When it is not desired to use steel beams, resort is frequently had to flitch-plate girders. They are, however, held in some disfavor by the building departments of the several cities, who do not consider that the combined strength of the timber and metal can be taken, and will only permit the strength of either the timber or metal to be used.

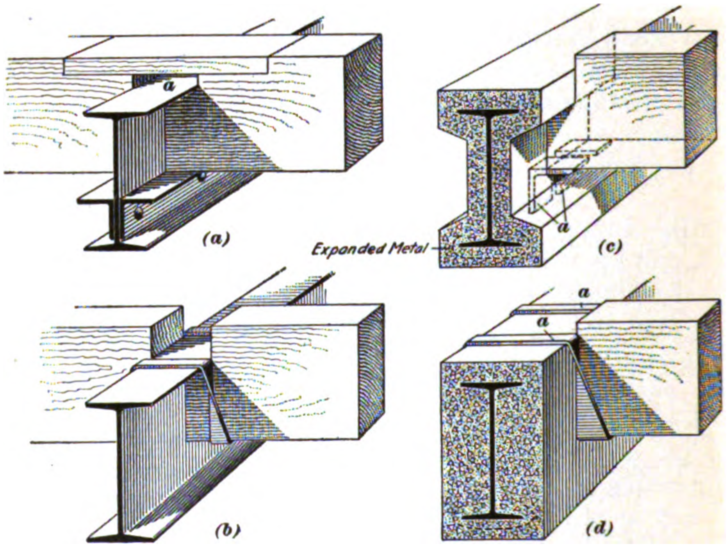


FIG. 24

51. The building departments of several of the large cities stipulate that buildings of the second class, which includes factory construction, shall not have steel girders that are not fireproofed supporting brick walls or floors. When this construction is required, the secondaries must be supported as in Fig. 24 (*c*). In this view are two angle brackets riveted or bolted to the steel beam, and extending through the concrete for the support of the wooden beams. While there is some danger of heat being transmitted to the beams through the projecting ends of these brackets, nevertheless it is considered better construction than that shown in Fig. 24 (*d*), where stirrups are used over the concrete fireproofing. In this latter construction, there is a liability of the stirrup bending at *a*, *a*, and crushing the concrete beneath. Where the reaction from the end of the girder is great, this undoubtedly is likely to occur, and such stirrups should be provided with a bearing plate on top of the concrete, so that their bearing at the edge will be distributed over a considerable area.

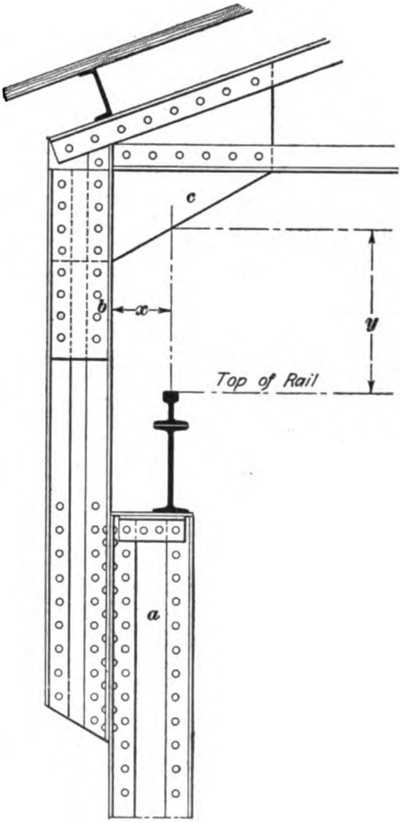


FIG. 25

TRAVELING-CRANE LOADS

52. Planning for Traveling Cranes.—In designing factories or mill buildings in which traveling cranes are to be installed, it is important to observe that the track of the crane can be properly supported, and also that there is sufficient headroom under the floor or roof construction to permit the trolley of the crane and the traveling mechanism of the crane girder to move underneath.

In Fig. 25, there is shown the upper portion of a steel-mill building. The columns *a* support the girder carrying the runway of the crane. A convenient means of supporting the roof is to splice to this column a similar column *b*, which is incorporated in the design of the roof truss and rigidly braced with the truss by means of a knee brace at *c*. In the design of such a building, it is very important to determine the distances *x* and *y* required by the makers of the traveling crane. These distances *x*, *y* depend on the size of the crane, that is, whether it is designed to carry 5, 10, 15, or more

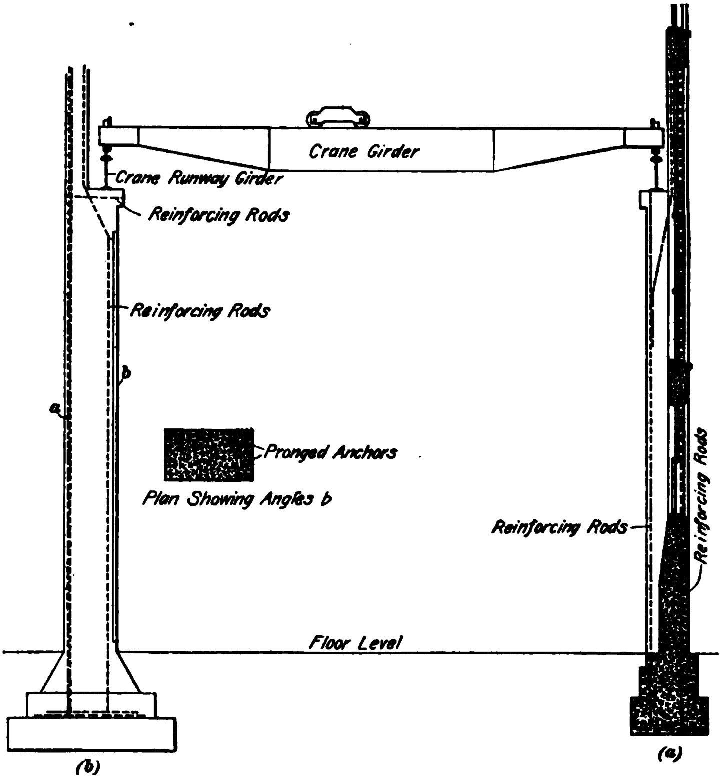


FIG. 26

tons. Usually from 9 to 12 inches is sufficient for the measurement x, while the measurement y varies from 5 to 8 feet.

53. Cranes Supported on Reinforced-Concrete Walls.—Frequently, in the latest types of construction, the runway for the crane is supported on reinforced-concrete walls, which construction is shown in Fig. 26 (*a*). It will be observed that the pilasters supporting the crane are strongly reinforced in all directions from which stresses are likely to be created from the eccentric load imposed by the crane track.

Where cranes are supported on reinforced-concrete columns, as in Fig. 26 (*b*), it would be good practice to put additional rods in the far side of the column as at *a*, in order to supply a greater resistance to bending, and thus counteract the effect of the eccentric load produced by the reaction from the crane track. Where cranes handle heavy rails or cumbersome material that might, by swinging, impose a blow on the reinforced-concrete columns, it is good construction to protect the edge of the columns with an angle iron as indicated at *b*. This angle iron may be fastened in the forms and anchored by means of pronged anchors back into the concrete when it is tamped.

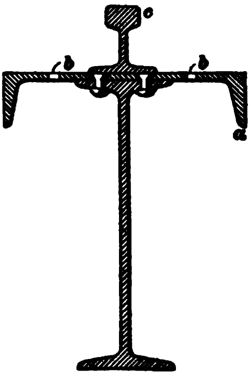


FIG. 27

54. Detail of Track Construction.—Many crane failures have been due to the spreading of the track between supports. It is better, therefore, to supply considerable lateral rigidity to the beam supporting the track or traveling crane. Where loads are heavy and plate girders are used for the runway tracks, the flanges of the girder are sufficient for this purpose. Where I beams are used, however, for the support of the crane track, it is good practice to place on the top of them and rivet with countersunk rivets, spaced about 18 inches apart on each flange, channel irons as indicated at *a*, Fig. 27. By means of these channel irons, which are drilled with open holes *b*, *b*, the rail *c* may be readily clamped in place by means of wrought-iron clips and bolts, and the rails nicely alined and adjusted by wedging between these clips and the track.

55. Maximum Stress on Track Girders.—The principal calculation for the construction of the runway of cranes exists in determining the maximum bending moment. The maximum bending moment on a runway girder occurs when the wheels of the traveling crane are in the position indicated in Fig. 28. It will be noticed that the center of the girder is midway between the center of the near wheel and the center of the crane trolley, that is, the distance *a* is one-half the distance *b*. The following formula will give the maximum bending moment on a crane girder when the load is in the position indicated in Fig. 28:

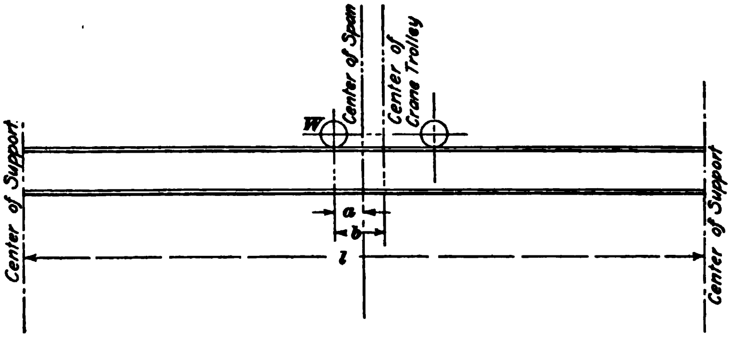


FIG. 28

$$M = \frac{w(l - a)^2}{2l}$$

in which M = bending moment, in inch-pounds;
w = load on one wheel of crane, in pounds;
l = span of girder from center to center of support, in inches;
a = distance, in inches, marked in Fig. 28.

In order to illustrate the application of this formula, assume that the wheel load w equals 10,000 pounds; that the distance from center to center of supports of the runway girder is 15 feet, or 180 inches; and that the distance *a* is 12 inches. By substitution,

$$M = \frac{10{,}000 \times (180 - 12)^2}{2 \times 180} = 784{,}000 \text{ inch-pounds}$$

From this bending moment may be found, by the methods given in *Design of Beams*, the proper size girder to use.

THE POWER PLANT

BOILER ROOM

56. Locating the Boiler Room.—The ideal location for the boilers of a factory or an industrial plant is in a separate building, which may be denominated as the **power house**, and which may include as well, the installation of the engines, dynamos, and other machinery necessary for the generation of power and its transmission. More frequently, however, the ground is not available for the erection of a separate building for the power plant, and it becomes necessary to install the boilers and engines in the factory itself. The location usually selected for these vital features of the mill is the basement, and the arrangement of the boilers and engines must be carefully considered in the designing of this portion of the building.

57. In laying off the space to be occupied by the boilers, the probable growth of the manufactory must be provided for by arranging ample space for the installation of additional boilers.

It is best in arranging the boilers, to face them toward the available coal supply, which is usually a coal bunker, vault, or bin, but in no instance must the front of the boiler be nearer to a wall than the length of the boiler tubes, unless special arrangements are made, for this distance must be allowed in order to draw any defective or damaged tubes and replace them with new ones. Also, by arranging the boilers thus, the fireman has a minimum amount of carriage for the coal.

58. Coal Storage.—In designing the coal vaults, or coal storage, their contents should be figured to allow for 1 or 2 weeks' coal supply, and as much more as is possible, to carry the plant over periods of existing coal shortage due to strikes or interrupted traffic from bad weather or other cause. In calculating the amount of space required for coal storage, it is sufficient to multiply the number of horsepower generated by the boilers by 4, which is the approximate number of pounds of coal per hour for the generation of 1 horsepower. This result, again multiplied by the number of hours for which the boilers are run at their capacity, will give the quantity of coal needed per day, in pounds. The weight per cubic foot of coal varies from 80 pounds for soft coal to 90 pounds for hard coal, so that by dividing the number of pounds by these quantities the cubic feet of coal required per day is obtained. The bins may then be proportioned for the number of days' supply which the judgment of the designer may assume as being necessary.

59. Ash Disposal.—Besides the consideration of the coal supply, some disposition must be made of the ashes from the boilers. Frequently, a bin is constructed of masonry, alongside of the coal supply, into which the ashes are dumped by means of barrows. In large plants, this bin can be emptied by means of an ash conveyer, or elevator, which will carry the ashes to the level of the street or railroad track and thence into a cart or car.

60. Planning the Boiler Room.—In locating the boilers in the boiler room, which should be done in the plans of the building, for it is not customary to cement the floor space covered by the boilers, and the cost of the building is thus reduced, a passageway not under 3 feet, and better 4 feet, should be left back of the boilers. This passageway is required in order to have access to the clean-out doors and the blow-off cocks. The ordinary horizontal return-tubular boiler, and some water-tube boilers, can be constructed in a battery, with as many boilers as may be desired in a row, especially when the passageway is left back of the boilers.

When setting other types of water-tube boilers, space should be left between each battery of two, for in these boilers, cast-iron doors are provided in the side walls for blowing the soot from the tubes, and access must be had through the side walls of the boiler for this purpose. It is therefore necessary in laying out the boiler space for boilers of this character to provide a passageway on one side of each boiler. In Fig. 29, a battery of return-tubular boilers is indicated, showing the clean-out doors for taking away the accumulation of

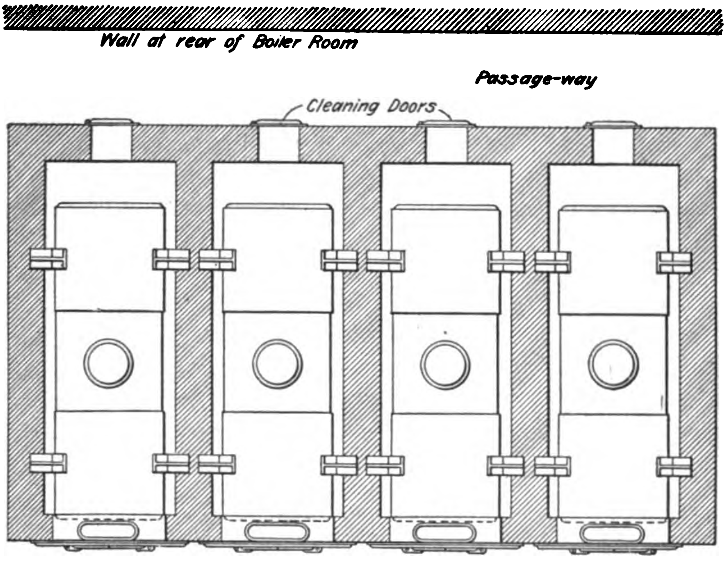


FIG. 29

soot and ashes that might be back of the bridge wall, through a passageway at the rear of the boilers. Some water-tube boilers are set in batteries of two, as the Babcock & Wilcox water-tube, land-type boiler, which is provided with the necessary clean-out doors, and doors for blowing the soot off the tubes in the side wall.

It is therefore necessary in laying out the boiler room of a manufacturing plant to consider carefully the character of the steam generator and study its requirements, so that it may be successfully operated and the proper spaces allotted.

61. Doorway to Engine and Boiler Room.—In the hasty design of buildings, it is frequently found that the size of the doorways is not sufficient to admit the boilers and machinery. This is a serious defect in the planning of a manufacturing plant, as it requires either the installation of the boilers and engines before the walls are entirely built, or else the tearing out of brickwork and jambs in order to accommodate them afterwards. An expedient for the enlargement of the headroom of doorways and openings into the boiler and engine rooms that are in the basement, is shown in Fig. 30. Here, if the lintel of the doorway *a* is kept below the floor level, where it would ordinarily exist, the headroom of the doorway will be materially reduced, and considerable difficulty will be encountered in taking any large piece of machinery, or a boiler or steam drum, down the

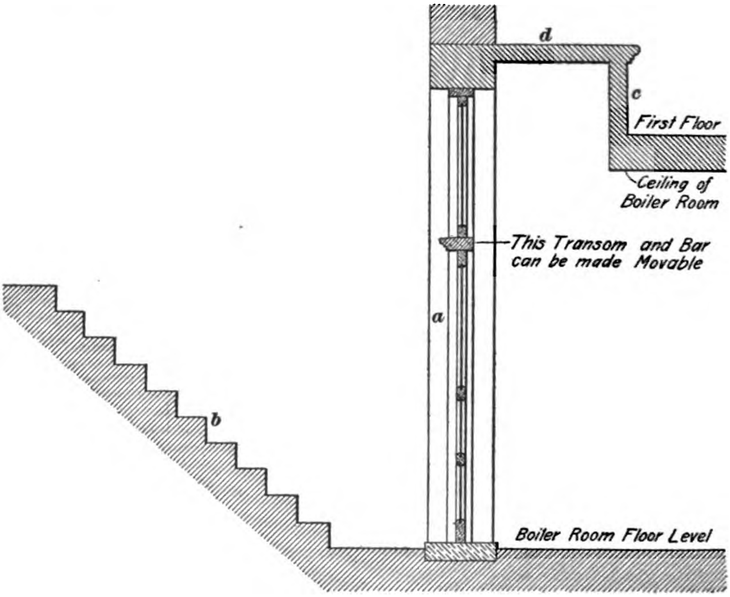


Fig. 30

steps *b*. The doorway is consequently increased in height by the introduction of the bulkhead at *c*; while by this means the floor space above is slightly reduced, yet use can frequently be found for the ledge or platform frame at the top of the bulkhead, as at *d*.

62. Floors Above Boilers.—It is important in designing boiler rooms in factories to have the floor construction over the top of the boiler of incombustible material, and it is customary in the better class of buildings to provide a section of fireproof floor over the top of the boiler room. This floor construction may either be a brick arch supported on steel beams, or hollow-tile construction, though reinforced concrete is now finding favor for this purpose.

63. It is not altogether necessary that the boilers in a building shall be placed in the basement, though as this is usually the least valuable of the floor space it is the practice to so locate them. In some electric-light stations, and in large factories, boilers have been located on the first floor, and even in several instances on the fifth and sixth floors. The exigencies that demand the latter installation, however, must be great, for it can be readily seen that much power must be expended in lifting the coal, etc. to the boiler room.

CHIMNEYS

64. Dimensions and Capacity of Chimneys. Nearly all the factory buildings combine in their structure a power plant, not the least important feature of which is the **chimney.** There are two things to consider in the design of a power chimney—first, its capacity for providing the necessary draft and the conduction of the requisite volume of gases from the furnace or boiler, and second, its stability. The first requirement regulates its diameter and height, and these dimensions, together with its construction, determine also its stability.

Considering the first requirement, a circular flue is considered more efficient than a square one, because its inside

TABLE I

Diameter Inches	Height of Chimneys and Commercial Horsepower Capacity											Side of Square Inches	Effective Area Square Feet	Actual Area Square Feet
	50 Feet	60 Feet	70 Feet	80 Feet	90 Feet	100 Feet	110 Feet	125 Feet	150 Feet	175 Feet	200 Feet			
18	23	25	27	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	16	.97	1.77
21	35	38	41	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	19	1.47	2.41
24	49	54	58	62	. . .	. . .	. . .	. . .	. . .	. . .	. . .	22	2.08	3.14
27	65	72	78	83	87	. . .	. . .	. . .	. . .	. . .	. . .	24	2.78	3.98
30	84	92	100	107	113	119	. . .	. . .	. . .	. . .	. . .	27	3.58	4.91
33	105	115	125	133	141	149	. . .	. . .	. . .	. . .	. . .	30	4.48	5.94
36	128	141	152	163	173	182	191	. . .	. . .	. . .	. . .	32	5.47	7.07
39	154	168	183	196	208	219	229	. . .	. . .	. . .	. . .	35	6.57	8.30
42	182	200	216	231	245	258	271	288	. . .	. . .	. . .	38	7.76	9.62
48	. . .	269	290	311	330	348	365	389	. . .	. . .	. . .	43	10.44	12.57
54	. . .	348	376	402	427	449	472	503	551	. . .	. . .	48	13.51	15.90
60	. . .	436	471	503	536	565	593	632	692	748	. . .	54	16.98	19.64
66	. . .	. . .	579	620	658	694	728	776	849	918	981	59	20.83	23.76
72	. . .	. . .	698	746	792	835	876	934	1,023	1,105	1,181	64	25.08	28.27
78	. . .	. . .	. . .	885	949	990	1,038	1,107	1,212	1,310	1,400	70	29.73	33.18
84	. . .	. . .	. . .	1,035	1,098	1,157	1,214	1,294	1,418	1,531	1,637	75	34.76	38.48
90	. . .	. . .	. . .	. . .	1,269	1,338	1,403	1,496	1,639	1,770	1,893	80	40.19	44.18
96	. . .	. . .	. . .	. . .	. . .	1,532	1,606	1,712	1,876	2,027	2,167	86	46.01	50.27
100	. . .	. . .	. . .	. . .	. . .	. . .	1,760	1,865	2,043	2,197	2,359	89	50.11	54.54
104	. . .	. . .	. . .	. . .	. . .	. . .	1,899	2,024	2,218	2,395	2,560	93	54.39	59.00
108	. . .	. . .	. . .	. . .	. . .	. . .	2,051	2,190	2,399	2,591	2,770	96	58.83	63.62
112	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,323	2,588	2,795	2,983	100	63.46	68.42
118	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,632	2,883	3,114	3,339	105	70.71	75.94
120	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,725	2,986	3,225	3,447	107	73.22	78.54
124	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,915	3,193	3,449	3,687	110	78.31	83.86
130	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3,165	3,467	3,745	4,004	116	85.04	90.76
136	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3,868	4,178	4,466	121	94.85	100.88
142	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4,305	4,567	4,886	126	103.69	109.98
150	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4,719	5,097	5,448	133	115.72	122.72

surface offers less resistance to the passage of the gases, and there is not the likelihood of eddies being formed. There is much difference of opinion among engineers as to whether a stack should be narrower toward the top or increased in size. The practice is to taper a stack toward the top, this being done more on account of the necessity for increasing its stability than because of the draft. Some stacks have been built, however, with a larger inside diameter at the top than at the bottom, with the idea of providing a greater sectional area for the passage of the gases as their velocity is decreased. The capacity of the stack for carrying off the products of combustion depends on the temperature of the inside gases as compared with the temperature of the outside air. The average temperature in stacks for power purposes ranges from 450° to 600° F., and, therefore, as there is little difference in the travel of gases in flues between these temperatures, Table I can safely be used in determining the diameter and height of stack for a given capacity of power plant.

In Table I, it will be observed that the capacity of the stack is given in horsepower, and in calculating this table it was considered that 5 pounds of coal were burned to develop 1 horsepower, this being a high figure with the present economical systems of power generation. Allowance has also been made, in this table, for the friction of the gases against the side walls of the stack, it being considered that a 2-inch layer of dead air exists between the stack lining and the gases.

65. Stability of Brick Chimneys.—In considering the stability of brick stacks, the overturning moment due to the wind must not exceed the resisting moment of the stack to overturning about the base. For instance, referring to Fig. 31, the pressure p due to the wind acts with the lever arm x about the base of the stack, tending to overturn it. The stack, or chimney, resists this overturning moment with its weight w, acting through a lever arm y; if these two moments are equal, the stack can be considered safe under the conditions considered, though it is better to have some factor of safety, 2 usually being sufficient. An easy formula by which to determine whether a stack is stable or not, is as follows:

$$w = \frac{h^2 \times dc}{b}$$

in which w = weight of stack, in pounds;
h = height of stack, in feet;
d = mean diameter of stack, in feet;
c = constant;
b = width of base.

The constant c varies with the shape of the stack. For a square stack, when the wind is blowing at hurricane violence, 56 is used; for an octagonal stack, 35; and for a round stack, 28.

To demonstrate this formula, consider a square chimney having an average breadth of 8 feet and a width at base of 10 feet, the stack being 100 feet high. The problem is, therefore, to find what the weight of the stack must be in order to resist the greatest wind pressure likely to occur. By substitution, in the formula,

$$w = \frac{100 \times 100 \times 8 \times 56}{10} = 448{,}000 \text{ pounds}$$

With brickwork weighing about 120 pounds per cubic foot, the chimney in question must therefore have an average thickness of somewhat more than 13 inches.

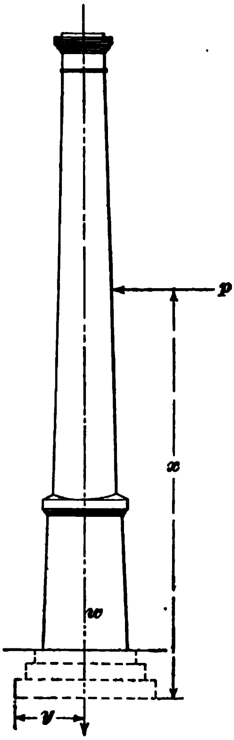


FIG. 81

66. A good rule to follow in designing brick stacks is to make the base at least one-tenth of the height. For stacks under 5 feet in diameter, the walls for the first 25 feet from the top may be 8 inches, increased 4½ inches for each additional 25 feet from the top. If the stack is more than 5 feet in diameter, the thickness at the top should be 1½ bricks, or

12 inches, with a 4½-inch increase for each 25 feet. If the stack is less than 3 feet in diameter, the brickwork for the first 10 feet from the top may be as little as 4½ inches; this thickness, however, is not recommended, as the weather is likely to penetrate such a thin wall, and sooner or later, together with the exposure to the gases, destroy the brickwork.

67. Construction of Brick Chimneys.—All brick stacks must be provided with a cast-iron or stone coping at the top, and it is usually well to tie them in toward the base with good heavy stone band courses. In constructing brick stacks, the brickwork should be laid up in lime-and-cement mortar, and the bricks well covered and slid in place, not just tapped or hit with the handle of a trowel.

All chimneys should also be provided, for a distance of at least one-third of their height from the base, with a fire-brick lining, laid up in fireclay, and at the bottom of this lining, where the flues from the boiler enter the stack, cast-iron cleaning doors and frame should be provided for removing soot that will accumulate and drop

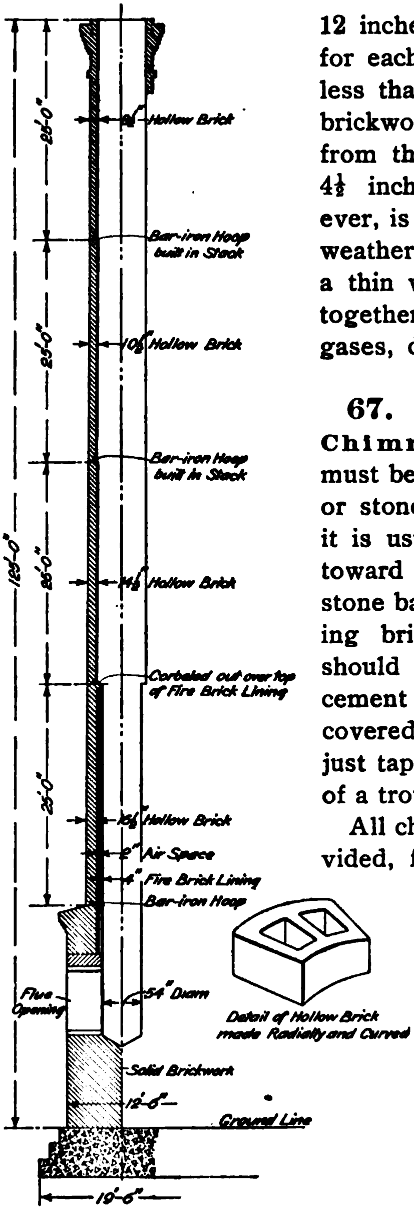


FIG. 32

down. A good example of a brick stack is given in Fig. 32; this stack has a capacity of 500 horsepower, and is sufficiently stable to resist any wind pressure.

FIRE-PROTECTION OF MILL BUILDINGS

SPRINKLER SYSTEM

68. Sprinkler Tanks.—In the large cities, where fire risks are great, and where nearly all the buildings and their contents are protected by insurance, the owners of the buildings are subjected to the rules and regulations of the Underwriters, or Associations of Insurance Companies. These Underwriters from time to time pass regulations insisting on certain further precautions and protection against fire, such as the installation of sprinkler systems, stand pipes for hose attachment for each floor, etc.

As the available city pressure or water supply of the municipality may be limited, or uncertain, or the pressure too low for a high building, it is sometimes necessary to place water tanks of from 10,000 to 30,000 gallons capacity in towers on the roofs of factories, and in the design of new factories provision is usually made for three tanks.

In designing a building, these tanks are located at such a point that their support is insured by the walls beneath, and the most convenient place is found to be over the stair tower or adjacent to it. As 1 gallon of water, together with the tank containing it, has a unit weight of 8 pounds, a 30,000-gallon tank complete will weigh in the neighborhood of 240,000 pounds, which must be supported on the walls and by means of iron beams.

The architect, besides providing adequate support for these tanks, must so design the tanks as to secure them against bursting, which would lead to serious consequences. For durability, sprinkler or fire-protection tanks are made of either cypress or cedar from 2 to 3 inches in thickness. They are usually in the shape of a truncated cone, and the bottom of the tank is required to be at least 20 feet above the highest point of the top story.

The important feature in the design of such tanks is to see that they are properly braced with hoops, and it is usual to specify that no hoop shall be subjected to a unit stress of more than 12,000 pounds for iron and 16,000 pounds for steel. These hoops are made from $\frac{3}{4}$-inch to 1-inch round iron, not less than the former, and the required strength is obtained by spacing them closer together at the bottom and farther apart toward the top. They are held together with adjustable clamps, as indicated in Fig. 33, and by the use of such clamps they may be readily tightened. The bottom hoops of the tank are subjected to great stress, and it is good practice for these hoops to bear against a flat iron hoop, as indicated in Fig. 34. By this construction much greater bearing is provided on the wood, and the round iron is prevented from cutting into the staves of the tank. In some instances flat iron hoops are used altogether, but it is considered better to use round iron hoops, from the fact that they are not likely to corrode through as rapidly as the thin flat iron.

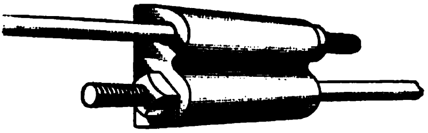


FIG. 33

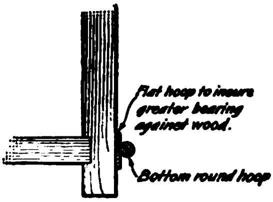


FIG. 34

69. Proportioning the Hoops.—The principal element of engineering entering into the design of large wooden water tanks consists in the proportioning of the hoops, and Table II will be found convenient in determining the hoops required for any size of tank.

70. In order to determine the number of hoops of a certain size required for any span of 12 inches at a point any distance from the water-line, the following formula may be used:

$$N = \frac{5.16\,d H}{S},$$

in which N = number of hoops required in 1 foot of height of tank;

d = diameter of tank, in inches;

H = height of water-line from center of space under consideration, in feet;

S = actual safe strength, in pounds, of hoops assumed to be used.

This last value may be found from Table II.

TABLE II

SAFE STRENGTH OF ROUND TANK HOOPS

Diameter Inch	Steel Pounds	Wrought Iron Pounds
$\frac{5}{8}$	3,232	2,424
$\frac{3}{4}$	4,832	3,624
$\frac{7}{8}$	6,720	5,040
1	8,800	6,600

71. To illustrate the foregoing, assume that it is desired to find what will be the spacing of $\frac{7}{8}$-inch steel hoops at the bottom of a tank 12 feet in diameter, in which the water-line is 16 feet from the middle of the section under consideration. Applying the formula in Art. **70**, using in conjunction therewith Table II, it is found that

$$N = \frac{5.16 \times 144 \times 16}{6{,}720} = 1.77$$

This result, 1.77, is the number of hoops required in 12 inches of height from the bottom of the tank, and would indicate that the hoops should be spaced about 7 inches from center to center, for 12 inches divided by 1.77 gives approximately 7 inches, the pitch of the hoops. This process should be repeated for different points throughout the height of the tank, and from the results the tank may be designed.

72. In the installation of sprinkler tanks, it must be observed that they are placed some distance above the highest point of the top floor, the distance usually required by the Underwriters being 20 feet, if it is possible of attainment. The tank should always be roofed, have a ladder from the roof of the building to its top, and a steam pipe inside to prevent the water from freezing in winter. This pipe is furnished with a check-valve to prevent the water in the tank from siphoning.

EXAMPLE FOR PRACTICE

What should be the spacing of the ¾-inch round wrought-iron hoops on a tank 10 feet in diameter and 12 feet high at a distance of 6 feet from the water-line? Ans. 12 in.

---

73. Automatic Sprinkler System.—The sprinkler system as now installed for protection against fire in the interior of a building consists essentially of piping connected to a gravity tank and extending over the entire ceiling by means of mains and branches. There is located on the ends of the branches automatic valves or stops, which are collapsed or opened by the melting of a fuse or solder at a temperature more than is likely to exist in the room at any time and still below that which would be created by an incipient fire.

74. The underlying principles of automatic sprinkler systems as stated by the Underwriters are as follows:

1. Buildings must be open in construction, free from concealed spaces, or places where water thrown from sprinklers cannot penetrate.
2. Sprinklers to be so located that their distribution will cover all parts of the premises.
3. Sprinkler piping to be of sufficient capacity and to have water under pressure in same at all times, except in case of a system where freezing is likely to occur, where an air lock is used.

4. An automatic supply of water of sufficient quantity and pressure available at all times.

5. Systematic, thorough, and intelligent care and inspection of the system.

75. Fireproof Windows.—It is frequently necessary, and in many cases required by law, and especially recommended by the Underwriters, to provide fireproof window frames and sash in walls exposed to great fire risk, or where it is necessary to admit light into elevator shafts or fire-towers. To meet this demand, several forms of metallic window frames and sashes have been evolved, and these sashes when intended as a fire-retarder are always glazed with wired glass.

76. Wired Glass.—The wire glass now in common use consists of heavy glass plate with wire mesh embedded in it. This glass is obtainable in polished, ribbed, prism, or mazed form, as shown in Fig. 35 (*a*), (*b*), (*c*), and (*d*), respectively. The plain glass, Fig. 35 (*a*), is used where the light is ample, and where it is desired for the occupants to see through the windows. The ribbed is employed usually in factories, and the ribs are generally run in a horizontal direction, so as to throw the light toward the ceiling and floor, thus diffusing it throughout the building. The prism glass is also employed in order to secure a greater diffusion of the light than is possible with the plain or factory ribbed glass, while the mazed glass finds favor where it is necessary to employ an obscured sash, which will still admit plenty of light and present a good appearance but yet cannot be seen through.

The glass used in metallic frames should not be less than $\frac{1}{4}$ inch, or, if polished, $\frac{5}{16}$ inch, and the embedded wire should not have a mesh larger than 1 inch and should not be less in size than No. 22 Brown & Sharpe wire gauge, which is the standard used in America.

77. Design of Sash.—In designing a sash for fire-retarder frames, it is necessary, in order to comply with the Underwriters rules and regulations, to observe that no single light exceeds 24 in. × 30 in. The metallic frames are generally constructed of No. 22 galvanized steel, while the sash are made of a lighter weight, generally No. 24. In unusual localities, where the frames are likely to be subjected to the influence of gases, with known affinity for iron or galvanizing, it is permissible to make the metallic frames of 18-ounce copper, though such frames are not considered the equivalent

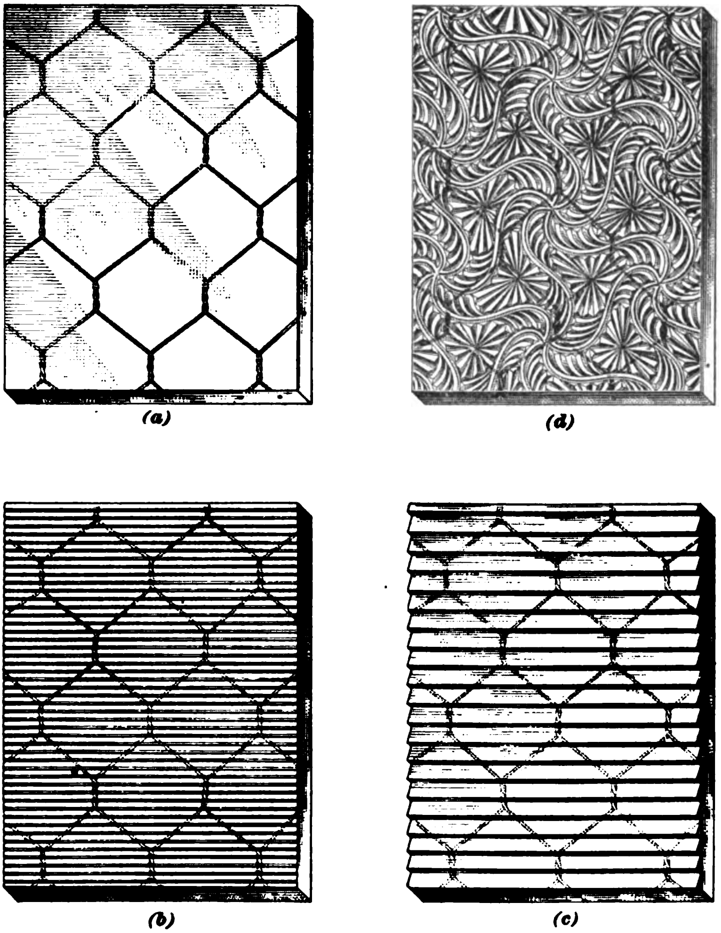


FIG. 25

of an iron frame as a fire-retarder, and such frames should never be used in elevator, vent shafts, or fire-retarder partitions that are liable to intense internal fires.

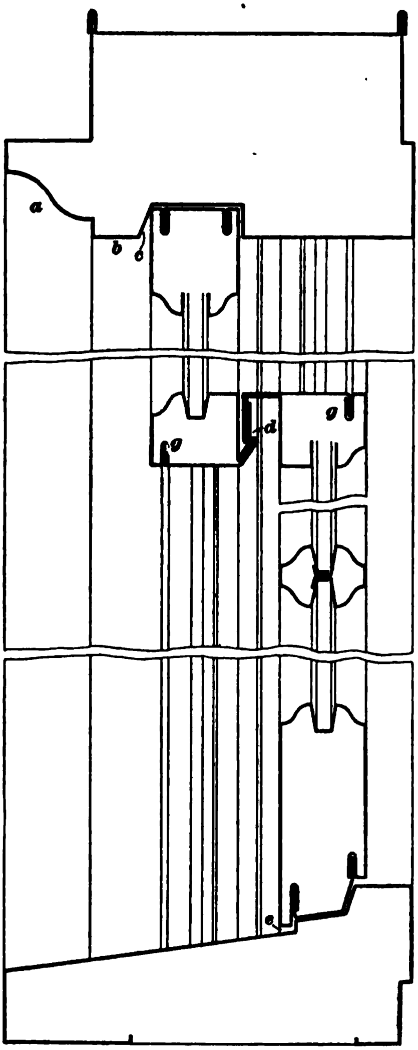


FIG. 36

In order to better explain the construction of the commercial frames, Fig. 36 is given, which illustrates one of the best frames in the market. In the figure, a vertical cross-section through the window-head sill and parting rail is illustrated. It will be observed that these frames can be neatly framed with architrave mold and stop, as designated at *a* and *b*. It will also be observed that the head for the top sash is beveled, as indicated at *c*, so that a tight joint is insured by the edge of the sash coming in contact with the bevel, and thus compelling a close connection. The parting rails are also constructed with a straight piece entering on a bevel *d*, so that at this point a tight joint is also secured. By the several offsets in the sill, wind and rain stops are provided, as indicated at *e*. Sashes constructed in this manner can be made to slide freely, noiselessly, and be made tight against weather and wind, as well as being secured against annoying clattering, or rattling. The sills of metallic frames are generally filled with cement, and sometimes the heads are similarly made solid. Any unusually large surfaces, like that which would occur between twin or triple windows, in the mullion, are securely braced inside with galvanized sheet iron or bar iron.

78. In the construction of metallic sash, solder is never used for holding the parts together, for all parts must be either lock-seamed or riveted, the lock seams being illustrated at *g, g*, Fig. 36. Soldering may be used only to fill up the joints. The objection to a joint that is only soldered and not lock-seamed is that in a severe fire when the window is subjected to an intense heat, the joint is apt to open by the solder melting out. When the joint opens, flames may go through and the fire-stop will thus be soon destroyed.

In designing the frames, they should have at least a 4-inch lap on the brick reveal on the sides and head, and it is not uncommon to wind-stop the sill by extending upwards a piece of galvanized sheet iron. While such windows as those described will act as a fire-retarder and prevent flames from reaching apartments that they protect, even in cases of severe conflagrations, nevertheless the glass radiates considerable heat, and inflammable goods should not be stored too close to such windows. Neither is it particularly desirable to have window shades secured to the frames of metallic windows. Where the goods in a building are particularly inflammable, the liability to pile them too close to the sash should be entirely eliminated by using window guards, which would maintain such merchandise at a distance of 3 or 4 feet from the window.

79. Fire-Doors and Frames.—There is no more important feature in the design of a mill building than the tin-lined fire-doors and their attachment to the jambs. Every fault in their construction, as viewed by the Underwriters, is likely to cost the owner additional insurance.

All tin-lined doors, when one door is used, should be made of three thicknesses of tongued-and-grooved planking, laid up and down and horizontally, and clinched-nailed, as illustrated in Fig. 37. The tin lining on these doors must be of IC tin, put together with locked seams, secretly nailed, and presenting the appearance designated in Fig. 38.

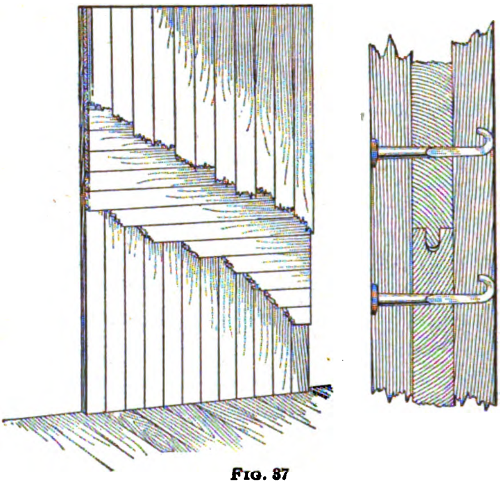


FIG. 37

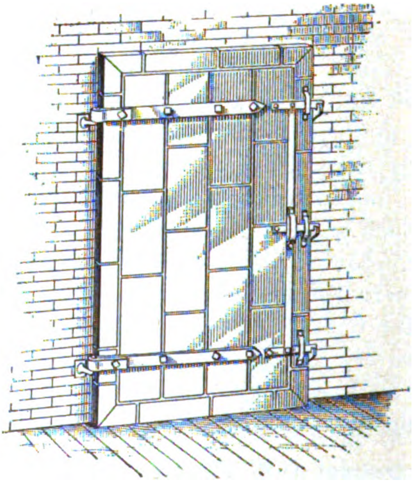


FIG. 38

80. The sills of openings covered with tin-lined doors must always project under the door, so that there is no danger of burning through the floor and thus communicating to the space protected by this entrance. The several constructions of sills most commonly used are illustrated in Fig. 39.

81. Sliding doors should be hung with anti-friction adjustable hangers. That is, the wheel of the hanger should have roller bearings for the axle, and there should be some means of adjusting the height of the door above the threshold by means of the hanger. The track for sliding doors should be placed on a slant toward the opening, so that the door will automatically close. Where it is desired to have the door open, it may be held back by means of a chord, fusible link, and counterweight.

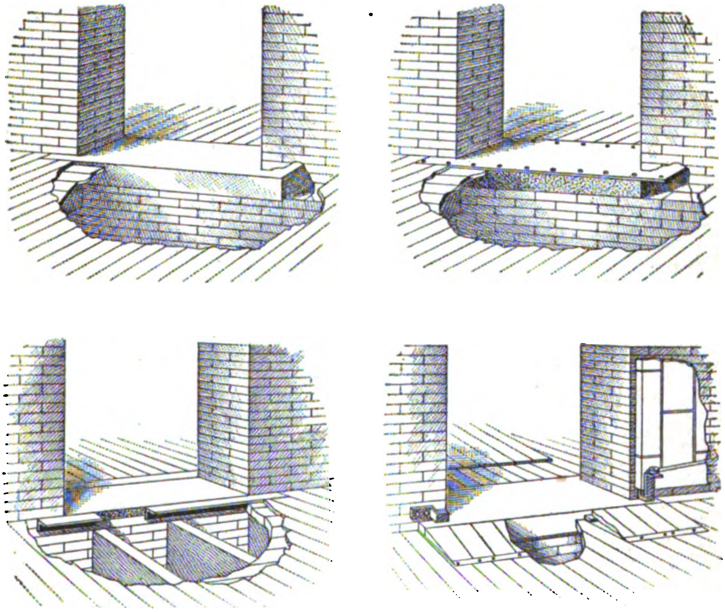


FIG. 39

82. All folding doors should be heavily strap-hinged, and secured to the jambs with iron-hanging stiles and hinge eyes with through bolts, as shown at *a*, Fig. 40.

Care must always be taken that any through bolts that go through brick walls near door openings, as the bolts shown at *a*, Fig. 40, be far enough away from the jambs so that there will be no danger of the bolts pulling through when put under strain. It is always better to build these bolts in the wall as the work progresses than to drill holes and put them in afterwards.

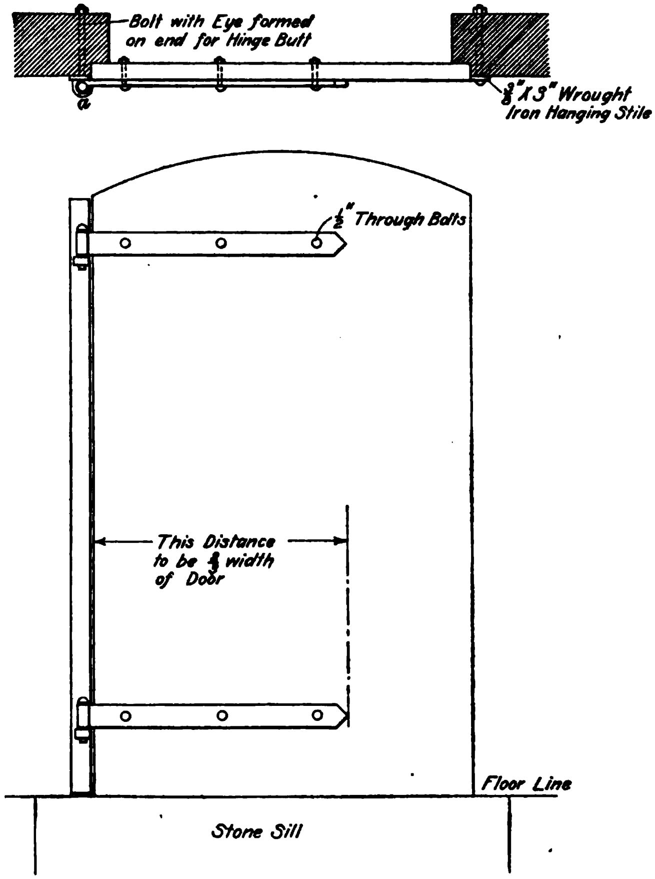

Bolt with Eye formed on end for Hinge Butt
a
$\frac{3}{8}$" X 3" Wrought Iron Hanging Stile
$\frac{1}{2}$" Through Bolts
This Distance to be $\frac{2}{3}$ width of Door
Floor Line
Stone Sill

FIG. 40

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